SCIENCE

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*METALLURGICAL LABORATORIES.**

To an old friend of the great captain whose munificence we celebrate to-day this privilege of adding a word of enthusiastic praise is most welcome. Let us congratulate Lafayette on this princely gift, and still more on the princely heart that prompted the princely gift. It is a pleasure to watch the growth and success of one whom we esteem; a very great pleasure to see the responsibility of that wealth which so often intoxicates where it should sober, so soberly and so wisely borne.

While the value of the metallurgical laboratory for purposes of investigation is evident, yet as instruments for teaching undergraduate students so few of these laboratories have been in long use, and their methods, aims and merits have been so little discussed, that not only the thoughtful part of the public, not only educators in general, but even a very large fraction of our metallurgical educators themselves, have but hazy notions about them. Indeed, there are many whose opinions cannot be ignored, many eminent metallurgical educators, who still doubt or even deny the value of the metallurgical laboratory for this purpose. Under these conditions it seems well that those of us

* An address delivered at the Dedication of the Gayley Laboratory of Chemistry and Metallurgy, Lafayette College, April 5, 1902.

who are confident that these laboratories are invaluable instruments should seize occasions like this to give the reasons for the faith that is in us, to the end that, if we are right, our allies, our sister schools here and abroad, may arm themselves with this potent weapon; and that, if we are wrong, we may discover our error through thus uncovering our reasons.

I ask your attention, then, to the use of these laboratories, not for purposes of investigation, for which their value is unquestioned, but for undergraduate instruction.

The objections urged against metallurgical laboratory instruction, so far as I understand them, are two:

First, metallurgy, like every other profession, has its art, and also its science, that is to say the systematic arrangement of the principles on which it is based. It is objected that professional education should be rather in the science than in the art, rather in the underlying and unchanging principles upon which the art reposes, than in the technique of the art itself. Principles, it is urged, are to be explained in words and thoughts, rather than in laboratory manipulations; they are to be imparted, then, by thought, by reasoning, by lectures and text-books, rather than by doing things with the fingers. The laboratory, it is urged, is no place to teach principles.

Second, the actual conditions of metallurgical practice on a commercial scale, that is to say the conditions of the art as it will have to be practiced, cannot be reproduced in any laboratory.

Let us examine these two objections.

The contention that education should be in principles rather than in the technique of practice, in the science rather than in the art, no educator worthy of the name can question. But this granted, the question remains how best to teach principles. To teach them effectively seems almost necessarily to require some conception of the things to which they relate; certainly, such conceptions must very greatly facilitate teaching. If the subject is of such a nature that sufficient conceptions concerning it have been formed during the student's prior life, then laboratory practice is less important or even superfluous; if not, if such conceptions are lacking or defective, then laboratory practice may be a most ready way of supplying or strengthening them.

Of the conditions attending metallurgy the student certainly has acquired no sufficient conceptions during his prior experience: his want here is more serious than in case of chemistry and physics; and because it is more serious, because these conceptions while hard to supply verbally, are readily supplied by laboratory practice, the metallurgical laboratory seems to me of the greatest value as a preparation to the study of the principles of this art.

Let us test this reasoning, this assertion that conceptions, if not a prerequisite, are at least an invaluable aid to the study of principles, of general laws. Surely, to grasp the principles of legislation there should be a conception of human nature; to understand the laws of music and painting there must be a conception of sound and color. Is not the same true then of chemistry and metallurgy, that in order to understand their laws the student should have a conception of the conditions and of the kinds of phenomena with which those laws deal?

The objection which at once arises is that, in case of mathematics no laboratory work is needed; that in case even of music and painting exercise in the art itself is certainly not necessary to enjoyment of its products, and probably not necessary to a clear comprehension of its principles. Why then in chemistry and metallurgy?

The answer is that the conceptions underlying mathematics, music and painting have already been acquired spontaneously, have become part of our very nature; and that in case congenital blindness or deafness has forcibly prevented the acquisition of the conceptions of color or sound, it has thereby made the study of the principles of painting or of music impossible.

Let us look at this a little more closely.

That every youth has acquired spontaneously and inevitably the conceptions underlying mathematics, the conceptions of number, distance, direction and force, seems clear.

The child deprived of every sense save touch begins with its first breath to familiarize itself with these conceptions. The resistance offered by fixed objects, the mobility of movable ones, the resistance which friction and inertia oppose to his moving them, the fact that he cannot move the bed post, that he can move his hand with ease, and his heaviest toy with difficulty, from the first give him the conception of force. The conception of two hands as distinguished from one is the conception of number, forced on him by every scene. Every glance of the eye, or if he is blind, every reaching out for toy or foot, gives the conceptions of distance and direction. These conceptions then are inevitable; they cannot be shut out by defects of the senses; hence the study of mathematics does not call for any special preparation comparable with the laboratory preparation for the study of chemistry and metallurgy.

So is it with music and painting to the child with all his senses.

The sighted youth comes to the study of painting with an eye trained from first infancy through sixteen hours of every day of most of his seventeen years, in color perceptions. They have been sunk into his very nature by the glories of the sunset, by the marvelous harmonies of the landscape, by the play of human expression, by the effects of shadow and perspective. He comes with conceptions so familiar and complete, so essential a part of his very being, that henceforth he cannot think shape without interjecting his conceptions of shade and color; he cannot conceive any object without conceiving it as colored or shaded.

To the study of the laws of music the youth with normal ear, the so-called ear for music, comes with the experience of seventeen years, those wax-like plastic years, of the sensuous pleasure due to certain sounds and sequences of sound, and the annoyance which others cause, not only to himself, but to those about him. The mother's lullaby begins his acquaintance with pleasurable sound; his own shrieks, the clanging bell, the squeaking slate pencil, early impress on him the disagreeable sound. So complete and familiar are his sound-conceptions that no special training in them is imperatively needed to enable him to begin the study of the science of music.

But let congenital blindness or deafness forcibly prevent him from acquiring these conceptions, and it thereby as forcibly and as absolutely unfits him for the study of the science of color or music. How can the congenitally blind, to whom red is but as the blare of the trumpet, comprehend a discourse on chiaroscuro? Or with what profit can you explain to them the proper tint of shadows while all conception of both tint and shadow is not simply vague, imperfect, rudimentary, but absent? Or how can the congenitally deaf understand the very terms harmony, discord, major and minor? Before they can conceive what minor means, must they not have some conception of sound?

Even after the missing sense has been given to one thus congenitally defective, to acquire the missing conceptions is a work of time. Open blind eyes at seventeen, and

all is seen in confusion; time and acquaintance must make conceptions clear and familiar, conceptions and interpretations of shade and perspective, before the science of painting becomes comprehensible. Unstop deaf ears at seventeen, and not only is a symphony of Beethoven absolutely meaningless, but all sound fails to be interpreted. Only after time has supplied the familiarity with sound conceptions which childhood should have given, only then can the study of the principles of music be begun.

These cases thus support the contention that familiarity with conceptions and conditions, if not absolutely necessary to the study of principles, is at least an invaluable, an incalculable aid.

The student beginning the study of metallurgy has something in common with one who should begin the study of the science of music immediately after the instantaneous cure of congenital deafness. As it is hard for us to grasp our own infantile difficulties in interpreting the sensations on our retinas, so one who begins to teach metallurgy late enough in life to have lost sight of the mental condition of his student days is at first puzzled by the density of his pupils' ignorance. They lack the very beginning of those every-day conceptions so familiar to the teacher himself. To a man from the moon the conception that water runs down rather than up hill would be novel.

Without conceptions of metallurgical conditions and surroundings, your reasoning about metallurgical processes may wring an acquiescence from the student's intellect, but all remains unreal, unheld by the memory, unimpressed, like a pale algebraic demonstration.

Now I take it that the great object of laboratory instruction is to supply lacking conceptions. Though the youth has seen chemical actions going on around him, his attention has not been sufficiently concentrated on their essential features. The chemical laboratory reinforces his deficient observation, and clarifies his hazy conceptions of gasification, sublimation, precipitation, solution, fusion, liquefaction, solidification, freezing, diffusion, the exact balancing of reaction, substitution, the indestructibility of matter. Beyond this it impresses on his memory the chief characteristics of the more important chemical substances by vivid picture, and by personal acquaintance, instead of by mere description from the lips or pen of teacher. They become to him as his playmates in the flesh, instead of as the heroes of his story books. It is no just reproach to call this kindergarten work; calling names is poor argument. It does to the youth what the kindergarten does to the little child, directing observation into fruitful fields.

Why, now, have I said that the need of laboratory instruction is even more pressing in case of metallurgy than in that of chemistry or of physics? Because the conditions, especially the high temperature conditions, which surround metallurgy are stranger, less foreshadowed by childhood's prior experience, less readily evolved from our consciousness, less easily pictured by the words of lecture or textbook than those which attend chemistry and physics as these are chiefly taught, the chemistry and physics of the normal or every-day temperature, that little range between the freezing and boiling points of water. The conditions and phenomena even of common-temperature chemistry and physics indeed are relatively unfamiliar to the beginner; this however is not so much because they and their likes have not been seen, as because attention has not been concentrated upon them. The pictures are already in the memory, and respond readily to developing and fixing by skilful language. The daily ablutions teach the in-

tegration of soap and certain dirt, and the insolubility of other dirt; sugar and salt at the breakfast table teach solution; the settling of fine mud in the brooklet's pools teaches decantation; the clearness of the spring exemplifies filtration; the tea kettle and soda-water teach ebullition; the drying roofs show evaporation; the sweating of the ice pitcher illustrates the principle of the dew point; the sponge teaches surface tension. All these and a hundred like images already exist in the memory, and have but to be recalled to become vivid, but to be interpreted to serve as types of our chemical and physical phenomena.

But of metallurgical conditions the youth's past has given little foretaste. Especially is this true of the solvent fluxing action of that high temperature at which the rocks and most of the metals are as water, many other metals are gaseous, and strength and even solidity itself are to be found in only a very few substances. And even these react energetically on almost everything they can touch. In the crucible of the iron blast furnace there is but one substance which remains solid, which can offer support, and that is carbon; but this itself reacts on most things exposed to it, and is in turn attacked and destroyed by them. This reciprocal destruction, this Kilkenny-cat attitude of nearly every available substance toward every other, is not only itself unlike anything the student has previously known, but it results in a difficulty previously unthought of, the baffling difficulty of devising any retaining vessel whatsoever. The solids we children have known stay put; the liquids rest peacefully in the familiar tin can, or, in the few cases in which this may not be used, then in vessels of wood, glass, porcelain or clay indiscriminately.

Indeed, the fiery magmas with which metallurgy has to do, the molten metal, molten slag and molten matter, are in themselves and apart from their corrosive nature substances unlike anything in the notice of our early years, which has been directed chiefly to solids and aqueous liquids. The nearest approach to acquaintance with this class is the hazy conception of lava streams of which we have read. Still more remote from our experience are the reactions between these plutonic bodies which play so large a part in metallurgy, the purifying action of slag on metal, the slag's retentivity of metal or of metalloid, according to whether it is acid or basic; the coalescing of the oxides and acids into one magma, the slag; of the sulphides into a second, the matte; of unoxidized and unsulphuretted elements, both metals and metalloids, into a third magma, the metal; and the reciprocal expulsion which each magma exerts towards the other. Here indeed we have a class of bodies and of reactions so unlike those of which the usual chemical laboratory instruction treats, that metallurgical laboratory practice should be added to chemical.

To supply clear conceptions of these strange metallurgical conditions, and thus to build a foundation for thought and reasoning, is I believe the chief work, the invaluable work of the metallurgical laboratory.

To build this foundation well, the student should, I think, perform a great variety of simple experiments, each of which should direct his attention to a very few or even to one important principle, and avoid diverting it to attendant administrative details. For instance, his furnaces should in general be heated by gas or electric resistance, so that his attention may be concentrated on the phenomenon which he is studying, and not diverted to keeping a coal fire in proper condition. As far as possible these experiments should be quantitative.

If I am right in saying that the laboratory is thus an invaluable instrument for

preparing the student for the study of principles, the first of the two objections urged against metallurgical laboratories, that education should be in principles rather than in practice, falls to the ground.

The second objection, that the conditions of actual practice cannot be reproduced in the laboratory would be unworthy of notice, were it not offered by men of such weight that even their errors must be considered.

The error lies in supposing that this instruction aims to anticipate practice in commercial establishments: whereas its aim is to facilitate instruction in metallurgical principles by lectures and text-books. There is no more reason for reproducing commercial practice exactly in the metallurgical laboratory than for reproducing in the chemical laboratory the system of kilns, towers and leaden chambers of the sulphuric acid works. But even from this mistaken point of view the objection is without weight. With equal force it can be urged that fire drill and military drill are useless, because they cannot reproduce exactly the actual conflagration, and the actual carnage and confusion of battle.

Another and important work of the metallurgical laboratory is to give a certain skill in the use of the instruments of precision of the art, in pyrometry, colorimetry and the microscopy of metals and alloys. It seems to me nearly as imperative that the metallurgist's diploma to-day should imply this skill as that the civil engineer's should imply skill in the use of the transit.

Finally, just as into a barrel full of potatoes a quarter of a barrel of sand can be poured, and then a quarter of a barrel of water, so after the student's power of study and note-taking in lectures has been thoroughly utilized, he still has power for much of this different, this observational and administrative laboratory work, in which he absorbs and assimilates priceless information like a sponge, and acquires along the path of least resistance and with but little mental effort the needed metallurgical conceptions.

HENRY M. HOWE.

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*A NEGLECTED FACTOR IN EVOLUTION.**

AN eminent Swedish zoologist, Dr. G. Adlerz, in a very suggestive paper† has recently called attention to some hitherto neglected conditions affecting the variability of organisms. Starting from the high degree of variability which has long been known to obtain in organisms in a state of domestication, Dr. Adlerz directs attention to the similar phenomena presented by wild animals during the great periodic increases in numbers brought about by unusually favorable trophic and meteorologic conditions.

In regard to the domestic organisms Dr. Adlerz gives expression to very generally accepted views when he says: "The changed conditions to which animals and plants are subjected in a state of domestication must, of course, mean a decided mitigation or even a complete cessation of the struggle for existence. They are provided with better and more abundant food than in the feral state and the survival of offspring is better insured. On the whole therefore the individual organisms are able to grow up under the most favorable circumstances.

"No matter how completely the germ-plasma may be shielded from external influences, it must, nevertheless, be susceptible to changes in the kind and amount of food, as Weismann admits, though he appears to lay little stress on this matter. If, as seems probable, variations are ultimately the resultants of physico-chemical processes in the germ-cells, it would seem to be very

* Contributions from the Zoological Laboratory of the University of Texas, No. 33.

† 'Periodische Massenvermehrung als Evolutionsfaktor,' *Biol. Centralbl.*, 22. Bd., No. 4, Feb. 15, 1902, pp. 108–119.

obvious that more abundant food must be responsible for the greater variability of domestic races. The organs, which in the feral state are continually exercised in a severe struggle for existence (in seeking food, pursuing prey, eluding enemies, in addition to other energy-consuming activities), do not under domestication compete so closely with one another for the less needed nutriment. Hence organs like the reproductive glands, which are not so directly implicated in self-preservation, are able to avail themselves of more food, and this should make possible, among other things, more numerous combinations of the varying elements. That greater abundance of food is thus one of the most potent, though indirectly effective, causes of variability in domestic races, may be regarded as an established fact, in so far as we are able to be certain of anything relating to this matter. It is a fact that the variability of these races in comparison with the conditions in a state of nature, has been enormously increased, and it would be difficult to point to any other factor in domestication of such decisive importance to the organism as surplus of food."

As Adlerz suggests in his paper, wild animals present certain peculiarities analogous to those exhibited by domesticated forms, viz., in the enormous numerical increase of periodic occurrence in many if not in all species. This increase must depend on conditions similar to those which produce a high rate of variability in domestic forms, *i. e.*, abundance of food and favorable meteorologic conditions. We should therefore expect to find a greater amplitude of variation as well as a greater number of individual variations during such increases than during periods of more limited increase. This is supported by the facts, as shown by Adlerz's observations on two such numerical increases in a butterfly (*Polyommatus virgaureæ*):

"These two increases in number were observed in the province Medelpad in central Sweden. The first occurred in 1896. That year the butterflies were seen to increase greatly during July till, by the middle of the month, they outnumbered all the remaining species of diurnal Lepidoptera. At the same time were observed a great number of a female variety not to be found in any other part of the country. This variety was distinguished by a series of light blue spots within the reddish-yellow band across the upper surface of the hind wings. The number and clearness of the spots varied greatly. The highest number was five, and from the varieties with the full number clearly developed, to the individuals of the dominant form, which had no spots at all, an uninterrupted series of transitional variations could be established.

"During the following year the species was not conspicuously abundant. Single individuals of the above described variety also appeared, but *they were both absolutely and relatively much rarer than among the increased number of the previous year.* Moreover, *no such marked variations were seen as on that occasion.* Hence the statement that *the amplitude of variation during 1896 was greater,* would appear to be admissible.

"During the past summer, 1901, the same species of butterfly reappeared in great numbers, and again, as in 1896, during the latter half of July the number of individuals was seen to exceed that of all the other diurnal Lepidoptera. And again the above-mentioned variety appeared in great numbers. By counting all the females among the numerous individuals that had settled on several large tansy patches, I found that many more than half showed the variation in question to a greater or less extent.

"These two numerical increases thus support the conclusion derived from theoretical

considerations, that during the increase of a species both the absolute and relative number of varying individuals as well as the amplitude of variation are increased beyond what is usual.''

The opponents of natural selection have often implied that conclusions drawn from domesticated animals cannot be used to explain the origin of varietal and specific forms among animals living under natural conditions. These authors seem tacitly to assume that the conditions of domestication are unique in that they can be realized only in human surroundings and under conscious human control. This, however, is not the case. The social Hymenoptera among insects, notably the ants, not only exhibit a form of domestication, as I shall endeavor to show, but also a pronounced and regular periodic increase in numbers. Thus they combine both the conditions for producing high variability, and furnish a brilliant illustration of the evolutionary factor to which Adlerz has called attention. Adlerz, who is well known as a myrmecologist, has, of course, utilized the ants to some extent in support of his views. He calls attention to the effects of feeding on the personnel of growing colonies. I believe it is possible in this connection to lay still greater stress on the facts. A considerable number of observations on colonies of different species of *Pheidole* have led me during the past three years to essentially the same views as Adlerz. As these ants beautifully illustrate the union of domestication and numerical increase and a concomitant high degree of variability, it seems best to record some of my observations and reflections in the hope that they may be of interest to those who are undertaking studies in variation.

It is now a well-established fact that every ant-colony is founded by a single fertilized female, or queen. The insect loses her wings and buries herself in a small cavity in the soil or wood that is to form the future nest. After entering the cavity she usually closes the opening so that she is completely shut off from the outside world. She deposits, at the expiration of a certain time, a number of eggs, and when these hatch as larvæ she does not go abroad in quest of food but feeds her offspring with substances regurgitated from her own body. These substances are ultimately derived from the fat body, a store of nutriment accumulated during her life in the maternal nest which she forsook to take the nuptial flight. Of course, the insect must derive her own nourishment from the same internal source and, as in all ants, the development of the young extends over a considerable period of time, it follows that the larvæ are of necessity poorly fed and after pupation hatched as dwarf workers (microërgates). The number, too, of these diminutive creatures is limited, so that the whole colony in this incipient stage is a family consisting only of the huge mother and a few dwarf offspring. These workers, though very timid, forthwith break through the walls of the chamber and establish relations with the outside world, whence they bring food into the nest and feed their half-starved parent. This food soon enables her to lay another batch of eggs, the larvæ from which are now turned over to the care of the workers. Being better fed, the second litter are able to reach a greater size before pupation and therefore give rise to larger workers than their nurses. The number of workers thus reinforced soon brings about a condition of affluence in the colony. The queen is more and more abundantly fed, and this, coupled with her confined and sedentary life, enhances her fecundity. The colony waxes strong in numbers and the workers of successive batches grow larger till they attain to the full stature of the species. Then, and not till then, do the

ants begin to educate the fertile sexes, the males and queens. Enormous numbers of these, in some species hundreds or even thousands, are produced during the most favorable season of the year, and all these individuals are carefully fed, groomed and guarded by the workers till fully mature and ready for the hymeneal flight.

If we look upon the ant-colony as a complex of more or less heterogeneous individuals, comparable to the Metazoan body, which is also a complex of units, the more or less differentiated cells, we may say that the sexual individuals of the ant-colony develop only under favorable trophic conditions, just as the sexual organs of the Metazoan mature only under similar conditions. While this analogy is useful it is also advantageous for present purposes to look at the sexual forms of ants under a somewhat different aspect, viz., as organisms that are educated to maturity in what is essentially a state of domestication. This is obvious when we consider that the males and queens are not only reared from the eggs, but fed, groomed and guarded by the attendant workers throughout their whole imaginal life in the nest. All these attentions vividly recall the attentions lavished by man on the animals of his household. One is especially reminded of this resemblance on seeing the behavior of the workers towards the sexual forms, just before the latter are ready to take the nuptial flight. The males and queens are permitted on successive days to take the air about the entrance of the nest. At such times they are herded by the workers like so many cattle, and hastily dragged or driven into the nest on the slightest suspicion of danger.* The fostering instinct which, in the ant colony, envelops both the mature forms and the young of all descriptions, constitutes the basis from which myrmecophily and the various forms of symbiosis in general have been developed. The extraordinary development of this fostering instinct is demonstrated by the interesting fact that no less than 1,500 species of Arthropoda are now known to live with the different species of ants on terms of amity or toleration.

The sexual individuals, when finally liberated from the nest, are thrown entirely on their own resources, and for a time the struggle for existence sets in with great severity. One has an opportunity of actually witnessing both catastrophic and personal elimination often on a magnificent scale. The struggle among the males for the possession of the females is intense. The lives even of the fortunate among the former are rapidly extinguished. The surviving, fecundated queens set to work to establish their colonies, an arduous and complicated undertaking which ruthlessly eliminates all the poorly equipped. Even before they can dig their nests hundreds of these insects are devoured by birds, lizards, spiders, etc. And many more of them die from exhaustion while digging their nests, or from hunger while raising their first litter of young, or from the attacks of subterranean predatory insects, parasitic fungi, etc. This struggle, however, terminates on the appearance of the first workers, and the successful queens thenceforth again lapse into a condition of domestication till the close of their often very long lives. These general statements concerning the formation and growth of the colony will apply to most if not to all ants.* They

* I have seen beautiful instances of this in the Texan agricultural ant (*Pogonomyrmex barbatus* Smith var. *molifaciens* Buckley) and in our northern species of *Lasius*.

* In a former paper ('The Habits of *Ponera* and *Stigmatomema*,' *Biol. Bull.*, Vol. II., No. 2, Nov., 1900, p. 68) I maintained that the Ponerinæ perhaps constitute an exception to the general method of establishing colonies, but I have recently found in a small cavity in a stone a fertile dealated queen of *Odontomachus clarus*

will also hold good to a considerable extent of the social wasps and probably also of the termites. The colonies of the former, however, are of annual instead of perennial growth like those of ants and termites. This is a difference of no little importance from the standpoint of our discussion, since it is readily seen that the conditions prevailing among ants and termites must tend to develop and strengthen the domesticating instinct to an extraordinary extent. This is indicated by the host of known myrmecophiles and termitophiles as contrasted with the few guests and parasites known to live in the nests of wasps.

The dependence of variability on the age and trophic status of the colony is most clearly seen in ants that have polymorphic workers. The huge, cosmopolitan genus *Pheidole, e. g.,* is particularly interesting in this respect. Its species are characterized by having workers of at least two very different aspects: minute, small-headed workers proper, and huge-headed soldiers, often of monstrous aspect. In a few American species (*P. instabilis* Emery, *carbonaria* Pergande and *vaslitii* Pergande) these two forms are connected in the same nest by perfect series of intermediates. In the vast majority of species, however, such transitions are very rare or altogether wanting. The queens of *Pheidole* are much, the males but little, larger than the soldiers.

The soldiers are put to different uses by different species. In the grain-storing species they function as the official seed-crushers of the community. The diminutive workers collect the seeds and store and move them about in the chambers of the nest. They are, however, quite unable to break the hard shells, which yield only to the powerful jaws of the soldiers. In the carnivorous species the workers bring in pieces of insects, while the soldiers act as trenchers and sever the hard, chitinous joints. In the above-mentioned American species with polymorphic workers, I believe that the transitional forms may also be of use to the colony as seed-crushers and trenchers, since the vegetable and animal food is of different degrees of hardness and the work of making it accessible is not thrown on a single caste as it is in the strictly dimorphic forms. In some species the soldiers undoubtedly deserve their name, for they run about with wide-open mandibles and attack any intruder with great fury. In other species they are very timid and make for the concealed chambers as soon as the nest is disturbed. They thus manifest an instinct which is highly developed in the sexual forms, especially the queens, whom the soldiers also resemble in certain morphological characters more closely than they do the workers.

Under ordinary conditions only the workers of *Pheidole* go abroad, while the soldiers remain at home and very rarely stray beyond the entrance of the nest unless the whole colony is moving to a new home.*

surrounded by five diminutive workers. While it is certainly remarkable that one does not find similar incipient colonies of our other Ponerinæ, this observation makes it probable nevertheless that the ants of this subfamily agree with the Componotinæ, Myrmicinæ and Dolichoderinæ in their method of founding colonies. Concerning the methods employed by the driver ants (Dorylii) and ants of visitation (Ecitonii) nothing is known. These remarkable insects are so secretive in all that relates to their household affairs that only time and lucky observation will be able to fill this gap in our knowledge.

* The *Pheidole* soldiers may leave the nest when needed as trenchers to carve the carcass of some insect that is too unwieldy to be dragged home by the workers. I have observed this in two of our smaller species, *Ph. vinelandica* Forel and *Ph. splendidula* n. sp. (allied to *Ph. metallescens* Emery). In the former case a caterpillar had fallen into a large ant-lion pit about three yards from the nest and had evidently been killed and partially consumed by the ant-lion. The carcass was covered with workers and soldiers busily engaged in cutting it into portable fragments. In

They are fed, groomed and guarded by the numerous workers of the colony and may therefore be said to live in a condition of domestication like the queens and males.

During the past three years I have had many opportunities to examine *Pheidole* colonies in different stages of growth, and my observations bear out the following general conclusions which agree with those advanced by Adlerz:

1. Both the morphological and color variations increase both absolutely and relatively in number as well as in amplitude with the increase in the number of individuals in the colony.

2. This increase in variability is also in direct proportion to the increase in the trophic status of the colony.

The truth of these statements will be apparent from a consideration of a few cases. The first offspring of the mother queen of a *Pheidole* colony consist of a few very diminutive workers only. The second batch of young, at least in one nest of *Ph. dentata* which I examined, were, with a single exception, also workers, though larger than those found in the earliest stage of colony formation. This single exception was a soldier, with a much smaller head than that of the typical soldiers of this species, and its coloration was that of the workers. In more advanced nests the typical soldiers make their appearance, at first a few, then more, till they are abundant in old and well-established colonies. But they never become as numerous as the workers, since the latter are being continually reared in considerable numbers during the whole life of the colony. It is easy to observe, without resorting to statistics, that the number and range in the color variations in both the soldiers and the workers keep increasing, and in polymorphic forms, like *Ph. instabilis,* the heads of the soldiers show a remarkable progressive enlargement and increased complication in the details of coloration and sculpture. I have repeatedly found incipient nests of this species containing only workers and the small-headed soldiers of different sizes, so that I was at first deceived as to the species of *Pheidole* I had before me. One nest, examined during the current year, contained only a single soldier of the extreme, large-headed type so characteristic of the species. Such soldiers appear in considerable numbers only in very large, *i. e.,* old nests, and it is only in such nests that one finds, during late May, the highest efflorescence of the colony, the hosts of males and winged females. The soldiers of the extreme type in *Ph. instabilis* assume a monstrous, one might almost say hypertelic, appearance, the head being so large in proportion to the body that it may lead to serious results to the insect. I observed that when one of these soldiers happened to fall on the back of its head in one of my glass nests, it was often quite unable to right itself, but stood on its head wriggling its tiny body and legs for hours till it could clutch at a passing soldier and thus regain its normal position.*

It is an interesting fact that the workers

another pit-fall in the same locality two large ants (*Camponotus sansabeanus*) were being treated in the same manner by the soldiers and workers of *Ph. splendidula.* These observations are suggestive in connection with the problem of 'communication' among ants.

* This observation suggested some experiments with isolated soldiers. When these are dropped on their heads from a little height on a smooth surface, like clean glass or polished wood, they are often quite unable to regain a footing. Many remain in this position for hours or even for two or three days, struggling at brief intervals and finally dying of hunger or fatigue. If a bottle, the inner surface of which is moistened with a drop of chloroform or alcohol, is placed over the insect, it is at first stimulated to the utmost exertion to right itself, but it often dies of suffocation without being able to turn over.

and soldiers of *Pheidole* species often vary independently of each other, in both form and coloration and it has long been known that this variation is not a correlative one, since the examination of many species has shown that it is impossible from a study of the soldier of a given species to predict the form, sculpture and coloration of the corresponding worker and *vice versa*. This is beautifully illustrated, so far as coloration is concerned, by the Texan varieties of *Ph. hyatti* Emery. In west Texas (San Angelo, Terlingua, etc.) both soldiers and workers are of a rich fulvous yellow. In central Texas, however, the workers are black or nearly so, whereas the soldiers may be yellow throughout, brown with pale yellow heads, or in other nests nearly or quite as dark as the workers. Not only do the variations among the soldiers become numerous and considerable only in older nests, but the same is also true of the workers. In large nests of an undescribed seed-storing species (allied to *Ph. pilifera* Roger), I recently found several workers (macroërgates) of the size and coloration of the soldiers, but without any tendency to increase in the size of the head or assumption of the sculpture of the soldiers.

Among the males and virgin queens, which do not make their appearance till the colony is mature—in some species of ants not till the second or third year after the colony is founded—we also find very pronounced variations. These are, of course, more significant, since they occur in individuals undoubtedly capable of reproduction. Here we must include the whole range of normal and pathological variations, such as the various transitional forms between the workers and queens (microgynes, pseudogynes, ergatoids, macroërgates) and the pathological transitions between males and queens or between males and workers (hermaphrodites, or gynandromorphs) as well as the normal males and queens of different sizes, structure and coloration. *It is a significant fact that all these variations, no matter how aberrant, are cared for and protected in the nest so long as they are capable of being fed.* They are enveloped by the general fostering instinct which is so characteristic of the worker ants, since it leads to conditions in such marked contrast to the well-known goring instincts of cattle and the weaker but nevertheless perfectly patent analogues among men. The following facts show that the motives for a tragedy like the *Œdipus Tyrannus* do not exist in ant-society. In one of my artificial nests there is a congenitally crippled worker of *Polyergus bicolor* Wasmann that is scarcely able to walk. Still for the past three months it has been carefully fed and cleaned by the workers of the enslaved species (in this instance, workers of two species, *Formica subœnesceus* Emery and *F. obscuripes* Forel). In the nest of a new species of *Leptothorax* I have seen a somewhat crippled lateral gynandromorph (male on the left side, with testis, worker on the right, with ovary!) that must have been fed and cared for by the workers as it was perfectly mature. Forel* describes a lateral gynandromorph of *Polyergus rufescens* that was moving in file with the normal workers and carrying a larva which it had pillaged. Here belong also the peculiar parasitized macroërgates which I described in a former paper.† These and many other cases that could be cited may perhaps make it easier to understand how monstrous neuter forms like the *Pheidole* soldiers could develop phylogenetically.

Several of the above mentioned variations, like the ergatoids and gynandromorphs, have not yet been observed in

* 'Fourmis de la Suisse,' p. 142.

† 'The Parasitic Origin of Macroergates Among Ants,' *Am. Natur.*, Vol. 35, 1901.

Pheidole species, but peculiar microgynes, or dwarf queens, certainly occur in some of the members of this genus. Emery* describes a dwarf deälated queen of *Ph. pilifera,* which was scarcely 3.5 mm. long. Normal queens of this species measure 6–6.5 mm. Emery's microgyne exhibited also an aberrant configuration of the epinotal spines. Recently Rev. P. J. Schmitt took two similar deälated microgynes in the nest of an undescribed *Pheidole* which occurs in Colorado and New Mexico. He kindly sent me one of these insects, which is smaller than any of the soldiers from the same nest. It measures only 2.5 mm., whereas a typical queen of the same species in my collection is 5 mm. long; and therefore eight times as large (in volume) as the microgyne. In this case the microgyne differs from the normal queen in color, pilosity and sculpture, so that had it been captured apart from the colony, it would certainly be regarded as the mother queen of a minute and very distinct species of *Pheidole.*

If it is true that the increasing variability exhibited by the *Pheidole* colony is the result of an increase in the number of its component individuals, and if this, in turn, may be traced to favorable trophic conditions, we should expect to find but little variation in colonies that are poorly fed and therefore unable to increase rapidly in number. This I find to be the case. In central and western Texas during the past autumn and winter the meteorologic and food conditions were extremely unfavorable, not only to ants, but to insects in general. Between September and the latter part of March almost no rain fell, and the protracted drought together with the cold of the winter months was very trying even to the ants that feed on stored seeds. During this period the number of soldiers in the *Pheidole* nests was found to be unusually small. In some nests of considerable size (*Ph. dentata*) they were entirely absent. One might suppose that the soldiers had died off on account of the unfavorable conditions, but this is improbable, because the vitality and hence also the longevity of the soldiers is superior to that of the workers, just as the vitality of the queens is much superior to that of all the neuter forms and the males.* I am therefore of the opinion that the scarcity of soldiers in the *Pheidole* nests was due to their not having been reared by the workers on account of insufficient food, moisture and warmth. Thus there was a tendency to suppress even the normal dimorphic variation of the neuter phase.

A peculiar Texan *Pheidole* (*Ph. lamia* Wheeler) may also be adduced as evidence of the inhibitory effects of unfavorable conditions on variability. *Ph. lamia* is a very small, timid species which lives a subterranean life under stones and feeds on dead insects, myriopods and crustaceans somewhat after the manner of the diminutive 'thief-ants' (*Solenopsis molesta* Say and *S. texana* Emery). It has the pale yellow coloration so characteristic of hypogæic species. Its very small colonies contain barely fifty individuals, and though I have found some eight or nine nests of this rare species in different localities and

* 'Beiträge zur Kenntniss der nordamerikanischen Ameisenfauna,' *Zool. Jahrb.*, Abth. f. Syst., 1894, p. 290.

* This is easily proved by observations on artificial nests that have not been supplied with the requisite food and moisture. In a nest of *Myrmica brevinodis* Emery which on September 14, 1901, contained forty virgin queens and five times as many workers, thirty of the queens but only two workers were still living March 14, 1902. *Myrmica brevinodis* lives in cool New England bogs, and it was difficult to maintain the right amount of moisture in the nest at all times during six months of very dry Texas weather. In this connection see also Lubbock's notes on longevity in ants ('Ants, Bees and Wasps,' pp. 41, 42).

have been able to capture the entire colonies, I have found in each case only a single soldier. This individual is of extraordinary aspect, its huge, cylindrical head being unlike that of any known species of *Pheidole*. In none of the nests have I been able to find a queen. As the abdomen of the single soldier is relatively larger than in other species of the genus, it is possible that this singular individual may produce eggs and thus replace the winged queen as the mother of the colony. The colonies of *Ph. lamia* certainly present a miserable appearance when compared with the teeming colonies of other species, and it is difficult to avoid the conclusion that the small size of the colony, the suppression of all but a single soldier and the possible elimination of the queens, are the result of unfavorable conditions. This ant is, I believe, really an effete or evanescent species, a species in what Hyatt called the phylogerontic stage.

Although many additional observations both of species of *Pheidole* and of other genera could be given, I believe that enough evidence has been presented to show that ants normally live under conditions eminently favorable to the production of variations and the preservation of these in the sexual forms till the latter are able to meet the exigencies of the struggle for existence with the best endowment of vigor and nutrition. We should therefore expect the ants to display a high degree of variability, and this is fully borne out by a study of these insects as a family in the taxonomic sense. Up to the present time the ants alone of all invertebrate animals have been successfully treated in taxonomy like the birds and mammals. The trinomial and quadrinomial nomenclature in the hands of Professors Emery and Forel admirably expresses the fine shades and relative stability of the form and color variations which can be recognized in these insects. It is safe to predict that a quinquenomial system may be necessary before long adequately to symbolize the still more delicate subvarietal deviations observed in different nests of the same varieties.

The importance of this high variability or plasticity from the standpoint of the development of instincts and intelligence, and in fact in all those life-activities which may be conveniently designated as *ethological*,* must be apparent on a moment's reflection. In my opinion the manifold and often wonderfully perfect morphological and psychological adaptations, which have made the ants the dominant group among terrestrial invertebrates, have their origin in the variability so greatly enhanced by the production of enormous numbers of individuals and the care and protection afforded, through a most important period of their lives, to the reproductive individuals of the colony. This is true no matter what views we may hold on the subject of selection since, so far as the substance of this paper is concerned, it may be immaterial whether we demand that there shall be many simultaneous variations of the same kind, that the variations shall be saltatory, gradual, determinate or indeterminate, whether we pin our faith to 'orthogenesis' or to Darwinism in its original form, to coincident ('organic') or to germinal variation. Any or all of these forms of variation may exist in the fully developed ant colony and, in all probability, also during the great periodic increase in numbers exhibited by many other animals.

William Morton Wheeler.

University of Texas,
March 19, 1902.

* In a forthcoming paper I hope to justify the use of this term as it is employed by some French zoologists in the place of the less satisfactory 'ecology,' 'natural history' and 'Biologie' in the German sense.

SOME SUGGESTIONS FOR THE IMPROVEMENT OF INSTRUCTION IN TECHNICAL CHEMISTRY.*

IN attempting to discuss so broad a subject as the methods of teaching technical chemistry employed in this country, one is met at the outset by numerous difficulties of interpretation. No two of the thirty-odd institutions claiming to prepare students for the practice of technical chemistry seem to agree on the topics necessary for study, the order in which these should be taken up, the extent to which any one should be cultivated, or the actual subject-matter of courses given under the same name; to say nothing of the non-chemical subjects in the curriculum, such as mathematics, literature, analytic mechanics and other 'strains and stresses.' In some colleges, chemical engineering seems to mean a mixture of less chemistry and less engineering than is required of either chemists or engineers; whereas in others 'analytical chemists' are turned out after one or two years' experience on 'unknowns and complex ores.' It is plain therefore that in order to arrive at any comprehensive view of actual and of desirable conditions, it will be necessary to define, in a manner somewhat more precise than is usually customary, the fundamental aims of technical education with reference to chemistry.

THE UNITY OF CHEMICAL PRACTICE.

Stated in its baldest terms, the aim of such technical education must necessarily be adequate preparation for professional practice. To be sure, this definition merely restates the problem itself; we must immediately ask, what do we mean by adequate preparation, and what by professional practice? Let us consider the latter question first. At first sight, the professional practice of the chemist appears as an exceedingly complex affair, incapable of closer statement; a chemist may be a mineral analyst, a food analyst, a metallurgist, a manufacturer of heavy or of fine chemicals, a gas-chemist, an electro-chemist, a pharmaceutical chemist, a dyer, a manufacturer of coal-tar products, a fermentation chemist, to leave out further subdivisions, and last but not least, a teacher of chemistry, perhaps the most technical of all. It will be said that this is far too broad a picture of the chemist's activity, and that the whole of technical practice may be summed up under three distinct heads: Analysis, manufacture, instruction. Indeed, it may be safely said that this represents the opinion of the majority of American and English chemists. And yet, the analyst, the manufacturer, the teacher are merely chemists, thinking by the same mental processes, applying the same general laws, attacking very similar problems, differing only in the accidental circumstances of the materials they work with. The analyst sacrifices time and money to the cause of accuracy; the manufacturer gives up accuracy for the sake of time and money; the teacher wears himself out in the effort to be accurate without wasting either time or money.

The fundamental unity of chemical practice is not a new discovery. It was 'made in Germany' some forty years ago; and although not patented, the Germans enjoy an exclusive monopoly of its use. The analyst, the manufacturer and the teacher are continually exchanging their experiences through a sort of chemical clearing-house. Young docents frequently spend two or three years in a factory for the purpose of broadening their knowledge; a factory sends its problems to the university

* Read at the Denver meeting of the American Chemical Society, August, 1901. This paper was written before the publication of Dr. McMurtrie's recent address to the American Chemical Society. It is gratifying to note the substantial agreement of both articles as to the problem set before our teachers.

laboratory to be solved. An investigator in need of expensive substances, or of mechanical appliances to handle large bulks of materials, need only apply to the nearest factory to have its machinery placed at his disposal, or its wares furnished at little or no cost. The largest factories have their own research laboratories, in which a hundred and more university graduates and professors spend months and years on single investigations, and are paid liberal salaries even if their results are technically worthless. One factory recently purchased the entire scientific library of Kekulé. The manufacture of nearly all the numerous coal-tar products consists merely of laboratory methods on a large scale; and the scientific problems solved in this connection have been of the utmost importance and benefit to 'pure' science. Certain large establishments prefer their chemists to have had training in pure science only, and then give them from three to six months of technical training in their own works *and at their own expense*. The specifications of chemical patents constitute an important section of scientific literature, and the German Chemical Society spends large sums of money for the purpose of abstracting and indexing them. If we also take into consideration the unquestioned preeminence of Germany in all branches of chemical practice, what better demonstration can we give of the fundamental unity of the profession?

PRESENT STATUS OF INSTRUCTION.

We are now in a better position to return to the former question: What do we mean by 'adequate preparation'? For no matter what may ultimately be agreed upon, it will be identical in its first two or three years for all classes of students. It is a great comfort to have this important point definitely settled in advance; for one of the main difficulties in arranging our college curricula has been the supposed necessity of providing two or more coordinate sets of courses in chemical instruction. This has been a great strain on the teaching staff as well as upon the financial resources of the laboratory.

An examination of a number of college catalogues brings out the fact that at present all students actually do follow essentially the same course for about two years. These courses usually consist of one or two terms of general inorganic chemistry and simple laboratory work, one or two terms of qualitative, one or two terms of quantitative, analysis; all these combined so as to occupy from two to three years at the rate of eight to fifteen hours per week. It would seem, then, that here we have the present American conception of 'adequate preparation'; for the subsequent courses are almost invariably special short ones in various branches of work. We may well ask: Is this preparation really adequate? I think not; but before considering it in detail as the main business of this paper, a few words must be said concerning these special addenda, the 'finishing courses.'

Even in some of our best institutions these final courses come perilously near the standard of the 'polite department' and 'philosophy' of young ladies' seminaries. There is an unfortunate lack of caution in the claims published in their catalogues. Lack of space prevents citation of many of the choice extracts I have found; two or three will suffice, however, for purposes of illustration. One college offers a course of *forty-four* lectures on the following topics: 'metallurgy, glass, ceramics, chemicals, illuminating gas, bleaching, photography, petroleum, brewing, wines and liquors, vinegar, fats and oils, essential oils and rosins, sugar, starch, glucose, milk, distillation of wood, paper tanning, etc.' One suspects that these lectures must

be illustrated with a kinetoscope. Another institution claims to prepare its students for 'metallurgy and mining, chemical manufactures, dyeing, bleaching, tanning, sugar-refining, etc., and for work as analytical chemists, assayers, or teachers of chemistry.' The claim is based upon *three lectures per week* for two years, and two laboratory courses of twelve hours per week each, *which may be taken in one year.* A third college offers a course of *three hours per week for one semester* in 'qualitative and quantitative examination of air, water, food disinfectants, baking powders, flour, bread, tea, coffee, cocoa, spices, milk, butter, lard, beer *and other subjects.*'

It may be objected to the above that college catalogues are notoriously optimistic. The fact would seem to be demonstrated; none the less, such exaggeration is of very questionable value, and should be discouraged for the benefit of the 'raw graduate,' if for no better reason. It would appear, moreover, that the majority of colleges consider training in analytical methods equivalent to complete technical training; nearly all of them give several courses in water analysis, analysis of fuels, iron and steel, etc. The importance of such analytical training is undoubtedly over-estimated; a student who must continually neglect the factors of time and cost in his work receives too one-sided a training. The same objection is to be raised to many of the so-called courses in 'technical work.' If they do not consider time and cost as the essential factors, they have no better claim to a 'technical' nature than the ordinary beginner's preparation of hydrogen or chlorine. But more of this later.

Let us now examine more closely the nature of that preliminary preparation which we have found to be so nearly uniform throughout the United States. In the way of lectures, there is always a course on inorganic chemistry, occasionally a short one on organic, infrequently a very brief treatment of 'general' or theoretical chemistry incorporated with the above or as a separate course. Modern theories and the details of organic chemistry are usually left for advanced and optional courses. The time spent on these lectures varies greatly; but perhaps a fair estimate is three hours per week for two years (of about thirty-five weeks each). In many, in fact in most, colleges this average is not maintained. The laboratory training includes one, very infrequently two, terms of general introductory work, ranging from three to six hours each week. On the whole, this course may be described as satisfactory. Then follows a course in qualitative analysis, averaging twelve hours per week for one or two terms. Recitations accompany it in many instances, mainly for drill in writing equations, it would seem. In a few of the better institutions, but only in very few, the subject is made to serve as a practical demonstration of the theory of solutions. Finally, from one to three terms are spent in quantitative analysis, also averaging perhaps twelve hours a week. The subject-matter of this last course also varies greatly with the college; at the best, there is included training on a few alloys, sulphide ores, silicates, and a number of volumetric methods on technical products. The feeling cannot be repressed that in this course results call for a disproportionate expenditure of time. It is with the training afforded by the above that the student proceeds to follow his natural bent, and to acquire the special technical skill needed for his professional activity.

OUTLINES OF THE PROPOSED IMPROVEMENTS.

The technical preparations of the teacher need not concern us further. Every college and university is practically a technical school for training teachers first of

all, and for training technologists only secondarily. Not that the training of teachers of chemistry is incapable of great improvement; but on the whole it is so much more satisfactory, that the improvement of instruction in other technical branches is more imperative. Moreover, taking as our major premise the essential unity of chemical practice, be it that of analyst, manufacturer or teacher, it follows that the main deficiency in the present training of our teachers is exactly the lack of knowledge we are deploring, and endeavoring to remedy. Should it be possible therefore to generate within the college walls the mental atmosphere of the busy world where *things* must be mastered as well as ideas, we shall also have ministered to the wants of the budding preceptor.

Having thus wearied you by a circuitous return to our starting point, in order to eliminate possible objections based upon differences in the point of view, let us again take up the question. 'What do we mean by adequate preparation?' If, in the following discussion, the proposals I have to make shall appear a trifle too radical, I trust you will bear in mind that they spring from a conscious and deliberate idealism; and should the views here expressed really prove to have a basis of truth, any merely practical difficulties will yield as surely as the difficulties of manufacturing indigo yielded to the idealism of the German professor.

I take it then that an adequate preparation for the technical chemist has been secured when (1) a sufficiently broad general foundation of inorganic, organic and physical chemistry has been laid in the class room and in the laboratory; (2) when the 'chemical instinct,' *i. e.*, the ability to think in chemical terms, has been developed; (3) when sufficient analytical skill has been attained to ensure accuracy in following new methods; (4) when enough preparative skill has been acquired to make any compound with maximum purity in maximum yield, at the lowest possible expense under given conditions; (5) when speaking acquaintance with current chemical thought, both pure and applied, has been reached; and (6) when time has been found to accomplish all this.

THE BROAD FOUNDATION OF CHEMICAL KNOWLEDGE.

First, then, as to the general foundation of inorganic, organic and physical chemistry, in the lecture room and laboratory. I think there can be no serious objection to the statement that the present equipment of our students in this line is too meager. The plan seems to be to give very elementary courses in all three subjects, and then to assume that this information will multiply by cell division in the laboratory atmosphere. Another very prevalent view among teachers is that if you only give the student fundamental ideas, the facts will take care of themselves. My own experience is that for the amount of time spent in study, the outfit of actual information about chemical substances is unreasonably small. The unfortunate policy of feeding students only on peptonized and malted facts may avoid mental indigestion in college, but it predisposes them to colic afterwards. Certain very prominent text-books have had a bad influence in this direction, by seeking to eliminate all possible difficulties of comprehension and any reference to partially solved problems. It is not uncommon for students to ask if they 'have to remember the names of those substances' in their lessons, after a few weeks with those books; indeed, the question is not unreasonable, if we consider that the names constitute the sole remaining difficulty. Again, both text-books and teachers seem afraid that the students will know too much, and prune out all except

matter of the first importance. To be sure, excess of detail must also be avoided if clearness of presentation is sought; but is not the present tendency somewhat too violent a reaction from the methods of our forefathers? One very prominent teacher told me some years ago that each year he takes up less material in his lecture courses; what will become of them in ten years more? It is the function of the teacher to guide his students *through* the maze of facts as through a crowded city, that later they may find their own way about; not to whisk them around in a closed trolley-car, on the globe-trotter principle.

One difficulty lies in the use of text-books which are really only elaborated outlines of a lecture course. The result of using such books is that the student's horizon is bounded by the cover-boards. A lecture must be straightforward and consistent, if it is to have any value at all; but the printed page can be read over and over again, and its details mastered gradually. The text-book alone can provide the large number of facts that must be assimilated; the lecturer's syllabus is properly a key to the text-book, and no more. The teacher thus has a perfect right to demand of his students a greater knowledge of detail than he himself presents in his lectures. Another obstacle to the absorption of the proper number of facts lies in the almost universal attempt to treat a subject once and for all. This does not seem rational; nor do the student's mental limitations make it feasible. To take up the metaphor of the crowded city, the first efforts of a good guide result in a general survey, pointing out the topography, main thoroughfares and most important activities. Then come historical landmarks, and those sights which distinguish this city from all others; finally a detailed study of each quarter, of special industries and of prominent people. We can follow no better plan in teaching a new science, giving a broad survey first, then repeat, filling in many new details, finally going over it a third and fourth time, if necessary. In this way the student's memory will be aided rather than over-tasked; the relationship of parts to the whole, one of the most difficult of problems to him, will certainly be clearer; and the relative importance of various topics will stand out prominently. Then we shall avoid the necessity of turning out 'chemists' whose sole acquaintance with chemistry as distinguished from analysis was formed in the freshman year, and discontinued immediately thereafter. Chemical facts ought to be systematically studied each year of the college course.

But little need be said in addition to the above concerning the laboratory work to be correlated with this plan. I should merely wish to emphasize that substances should be studied from the preparative, analytical and physico-chemical sides simultaneously; the artificial division of the science for purposes of classification should influence the course of instruction little, if at all, during the first two years.

THE CHEMICAL INSTINCT.

Chemistry is a science which reasons about facts through a medium of abstractions. We observe colors, smells and precipitates, and we talk about atoms, molecules and space configurations. The thinking chemist must continually bridge the gulf that lies between fact and fancy; if he can do this freely, and avoid metaphysics, he possesses the chemical instinct. To develop this instinct in the student is the most important, and most difficult, problem of the teacher. Aside from intuitive, inherent teaching power, I know of but one plan for fostering this instinct: every topic should be presented in the form of a problem. Chemistry has advanced to its present proportions because of the

problems presented to it; all research work is a series of correlated problems; the installation of every manufacturing plant, of every new process, the regular operation of every established factory, is a series of problems; every analysis for whatsoever purpose is a problem; teaching is one vast problem. The main preliminary to the solution of any problem is a clear and complete realization of its nature. What is aimed at, what are the difficulties, what means are available? These questions should be as definitely in the mind of the student at every point of his college work as they must necessarily be in his later professional activity.

ANALYTICAL SKILL.

Perhaps no portion of chemical instruction is better given than training in analytical work. Methods have been worked out with such precision, and mechanical aids are so perfect, that given time, patience and care, anybody may become a fairly skilled analyst. Moreover, teachers seem agreed that introductory work both in qualitative and in quantitative analysis should precede all special analytical courses. Perhaps it may seem superfluous to offer any suggestions for the improvement of this portion of chemical training; I shall discuss this later. At this point I wish to speak of these special courses. It has already been shown that they constitute the crux of the 'technical' training of this country. It seems to me that they tend to destroy the unity of analytical practice by inducing the student to specialize far too narrowly and far too soon. Students often spend the whole of their third and fourth years at college on these courses alone, and thus deliberately sacrifice the sole opportunity of their lives to acquire a broad and thorough training for all future emergencies. I have known students at one of the largest universities of the land to avoid all courses on theoretical and organic chemistry, on the ground that they would have no use for them at a blast-furnace—that college sending most of its graduates into the iron industry. Surely no college should thus encourage its students to neglect their opportunities. A little of the wise and far-sighted cooperation practiced by German employers would furnish immediate relief from this state of affairs. Experience has shown that the employer does not suffer by choosing broadly-trained chemists in place of stall-fed analysts.

Besides, most of the 'technical methods of analysis' taught in our colleges have a way of getting antiquated. Each year witnesses some new committee of technical societies for the purpose of improving analytical methods. By the time these methods get into the text-books (copper plates being valuable), another committee is under way. If such analytical instruction is reserved until the last term at college, and then based upon the reports of these committees, the student will be more likely to acquire really useful knowledge, and have more time for broader study.

PREPARATIVE SKILL.

Until quite recently the only training in the preparation of chemical substances was afforded by organic chemistry; latterly, a number of colleges have introduced courses in inorganic preparations as well. These courses constitute excellent discipline, as far as they go; they do not go far enough. The actual preparation of chemical substances may serve three purposes. It may be intended to place the substance in the student's hands for study; if no more is sought, it is often cheaper and always quicker to furnish it out of laboratory stock. It may be intended to illustrate the reaction. In combination with the first purpose this end is eminently de-

sirable for beginners; for advanced students it wastes too much time in proportion to the result—such illustrations would be met as well by the use of chalk and blackboard. And finally, it may be intended as a study of chemical technology. As such it must inevitably take cognizance of the aims of technology, which are to prepare a substance in given grade of purity from the *available* 'Ausgangsmaterialien' at the smallest cost of time and money. It involves a sufficiently complete knowledge of the materials employed, strictest economy of time, labor and reagents, the demonstration of the required purity, and a calculation of cost and value. If a substance be prepared along these lines, to the amount of one gram or of one ton, it constitutes an exact duplicate of technical methods. The factory may employ cast-iron vats in place of flasks, and filter presses in place of funnels; it is not the more 'technical' by virtue of its appliances.

It will be objected that no university can make soda-ash or sulphuric acid on technical lines. To be sure; but it need not attempt to. The first condition of success in any undertaking is a clear understanding of one's limitations. The college cannot do much more than teach the factory spirit; if it does that much well, enough will be accomplished at present. Moreover, chemical industry is not limited to the production of heavy chemicals at the rate of fifty tons a day. Innumerable substances are manufactured in relatively small quantities, and by methods which do not differ widely from standard laboratory manipulations. These are wholly within the power of the college. I would propose that each college inaugurate as a part of its curriculum, required of all its graduates in chemistry, a full year's course in the actual economical preparation of laboratory supplies. It can manufacture most of its own 'C. P. reagents, ammonia and its salts, the products of the rarer minerals, ether much more cheaply than it can be bought or imported under existing revenue laws, and practically all its organic preparations, from a few technical products. Even if it should cost a little more to make these substances than to buy them, the gain in actual experience to instructor as well as to students is worth the extra cost. The equipment for this work need not be expensive. For the C. P. reagents, for example, the same outfit of large evaporators and crystallizing dishes, solution tanks and filter-presses can be used. The need of great care in cleaning these out for use on different materials would be an excellent feature of the work, to be controlled by analysis. By systematic planning, the laboratory could manufacture from thirty to sixty substances a year, in quantities to last five years; at the end of that period it would have supplied all its wants and could begin the cycle over again. In one year of such work the student would gather more experience than a factory would yield in ten; for no factory can undertake to slow down its procedure for the benefit of a novice.

In connection with this laboratory instruction, the usual lectures on chemical technology will certainly be more fruitful of results. Such lectures should not be omitted, nor anything else likely to broaden the student's acquaintance with facts. Indeed, these lectures are able to supply information not obtainable in the factory, viz., the *comparison* of factory methods, and the deeper principles that underlie all technical work and are taken for granted —the business world drives them home with a club. Finally, it need hardly be said that *frequent* visits to every establishment within reach should be a constant feature of technological training. In my own college course the 'frequent visits' materialized just *once*, when three large factories

were visited in the course of two hours—another illustration of the optimism of college catalogues.

ACQUAINTANCE WITH CURRENT CHEMICAL THOUGHT.

The necessity of familiarizing students with new facts at first hand is self-evident, and realized by all conscientious teachers. The main difficulty would appear to be the accomplishment of the task. I know of only one method—to weary not of well-doing, and to keep everlastingly at it. Frequent meetings of students and instructors on an informal basis, be it a seminar or a 'chemical society,' where new facts are discussed without reference to their classification, comprehensive lectures on recent progress, essays by the students themselves, the current numbers of journals laid out in a cozy reading room *in the laboratory* (the librarian must be overcome by fair means or foul)—all of these methods persisted in for two or three years will solve many a 'complex unknown' cerebral obstruction. *Ad astra per aspera.*

WHERE TO FIND THE TIME.

The ambitious program I have outlined now calls for the consideration of a purely practical problem: How can we find the time to accomplish all this? Even as our courses stand, there is barely time within the four years at college to complete the minimum of chemical work; where is there room for all the extra lectures and laboratory exercises that a really thorough technical preparation would seem to call for? I am afraid that my suggestions will contain many heresies.

For one thing, our college authorities must be made to realize that the main essential of training in technical chemistry is a knowledge of chemistry. This somewhat axiomatic doctrine is by no means universally accepted. Thus, the chemical engineers in two prominent institutions (Columbia and Pennsylvania) take considerably less chemistry than other students in chemical branches. Now while other topics are certainly necessary and valuable assets for chemical engineers, there must be a limit somewhere. The main problems before even the chemical engineer are chemical; those of the teacher and analyst almost wholly so. I will not presume to outline just how much or how little of these extraneous courses should be incorporated in the curriculum for technical chemists; but I should like to venture upon the principles which may fitly guide those more directly concerned with the task. I should say, then, that the question should be considered upon its own merits; no inherited prejudices, no educational theories, should stand in the way of the prime fact that in studying chemistry a knowledge of chemistry comes first. The problem of general education and culture must not be allowed to interfere in any way; where cultural education is also sought, the time needed for it must be debited to its own account, and not written off the technical calendar. The two problems are absolutely distinct, and have no business with each other. This must be insisted upon, since college faculties are only too prone to ignore it altogether. Better for a college not to give any technical courses at all, than to play at make-believe and ruin the careers of its graduates. If four years at college are not enough for both general and technical education, take six, eight or ten—but take enough to do the work thoroughly. I would say also that the non-chemical subjects should be reduced to the lowest possible figures, and chemistry be given the benefit of every doubt. Wherever feasible, these subjects should be a part of the general education, and thus serve both ends; such would be, *e. g.*, German and French, physics, first-year chemistry, mathematics, etc. The cardinal rule should always be

kept in mind, that it is better to know one thing well than to have a smattering of many and command of none. We must not expect to see in each of our students a Helmholtz or a Ludwig Mond; if any of them are destined for such versatility, they will have little need of our poor instruction.

One solution of the time problem, then, is to insist that enough time must be granted, and all extraneous matter reduced to a minimum. By the same token, however, it behooves us as conscientious chemists to do our best to shorten the time required for our own subject—for the benefit of the student, it might be observed, not for the benefit of the college faculty. By the aid of one further heresy, I feel able to indicate where an important saving of valuable time may be accomplished. I would abolish from the curriculum the study of qualitative analysis, the arch-type of anachronisms. We owe a tender feeling to the kindly nurse who brought us up carefully, and taught us the dark ways and vain tricks of the phosphates; but our nurse is old and decrepit, and no longer able to guide the toddling steps of the beginner. It will not be difficult to prove this. The study of qualitative analysis is intended to give knowledge of a useful art, and specific exercise in chemical thinking. It achieves neither purpose.

SYSTEMATIC QUALITATIVE ANALYSIS AS A USELESS ART.

The problem of systematic qualitative analysis as taught in our schools is to recognize all the ingredients of a given mixture. As a matter of fact, however, how much of this art have we achieved? We are able to recognize a limited number of inorganic acids and bases under special circumstances; and the instructor must exercise great self-restraint not to make his unknowns 'too hard.' As for the rarer acids and earths, to say nothing of the vast bulk of organic compounds, as well as for the commoner acids and bases in the presence of these latter substances, we must admit our inability to follow any comprehensive 'scheme' of analysis. The analysis of such mixtures resolves itself into a series of special tests, and our only check upon the correctness of the analysis comes through the quantitative necessity of finding one hundred per cent. of the ingredients. This limitation is clearly recognized by the professional analyst. Thus the chemists of the U. S. Geological Survey never carry out qualitative analyses of the rocks they investigate; they assume that all of some twenty or thirty ions are or may be present, and check the absence of any one during the progress of the quantitative analysis. Nor do they undertake to analyze one single sample for all of these thirty ingredients; two or more possible ones constitute a group that is examined by itself, without reference to the other contents. Again, the analyst is seldom, if ever, called upon to make a complete analysis of an absolutely unknown brew; on the contrary, he is usually asked to estimate some two or three ingredients, whose presence is either known or whose absence is to be demonstrated. The assayer never makes other than a quantitative analysis of gold and silver ores. For the food analyst, all is grist that comes to his mill—moisture, fats, carbohydrates, proteids and ash.

Where then is our boasted art of qualitative analysis? And where the need of dragging every chemist through the wearisome unknowns, so fearfully and wonderfully made, the like of which man never saw before nor will again? Why spend from two hundred to four hundred valuable hours to teach an art which does not exist? At the same time, it will be objected, the numerous qualitative tests referred to must be learned, and as well this way as any other. Not so; the important qualita-

tive reactions of all the important substances should be studied in the first instance, when the substances themselves are studied—not be kept on ice for a 'systematic' course. In the laboratory instruction in elementary chemistry time can be found for the methods of recognizing the acids and the metals the student works with, while he is working with them. We must counteract our mania for subdivisions and classifications, and teach chemistry as a unit. To be sure, the regular 'scheme' for the metals and acids is a useful thing *occasionally,* and students ought to be familiar with it; but it can be taught in one week to any student having a fair supply of analytical reactions among his mental baggage. I would teach these reactions by the side of a course in chemical preparations, rather than in a course by themselves.

QUALITATIVE ANALYSIS AS AN INFERIOR DISCIPLINE.

The intrinsic value of qualitative analysis is thus seen to be small. Its pedagogic merit is not much greater. As a matter of fact, teachers know only too well that it requires herculean exertions on their part to prevent students from rushing through the course mechanically. The majority of text-books are the merest skeletons of outlines, omitting a vast bulk of details 'because they interfere with a clear grasp of the subject.' One is strongly reminded of the way Latin is—or used to be—taught: the object being to reproduce its literature and culture, the literature and culture are left out to have more time for the syntax. So with qualitative analysis: the object being to train analysts, the analytical facts are left out to have more time for the system. Nor are we alone in our troubles; permit me to quote from the recent vice-presidential address of Professor W. H. Perkin to the British Association:*

"It has always seemed to me that the long course in qualitative analysis which is usually considered necessary, and which generally precedes the quantitative work, is not the most satisfactory training for a student. There can be no doubt that to many students qualitative analysis is little more than a mechanical exercise; the tables of separation are learnt by heart, and every substance is treated in precisely the same manner; such a course is surely not calculated to develop any original faculty which the student may possess. * * * I question whether any really competent teacher will be found to recommend this system as one of educational value or calculated to bring out and train the faculty of original thought in students."

With this quotation I am content to rest my case.

WHAT SHALL WE SUBSTITUTE FOR IT?

One important question remains. The art of testing unknown substances must always be an integral portion of the chemist's outfit; if the present course, designed for that very end, fails to teach it, what alternative have we to offer? The plan I venture to suggest may be found worth a trial.

I propose, first of all, to annul the divorce of chemical analysis and chemical preparation. Many colleges now introduce quantitative experiments into their *beginner's* course, such as (I quote in part from a circular issued by a conference of teachers at Chicago in 1896): definite proportions by volumetric methods, multiple proportions from the oxygen evolved from potassium chlorate and perchlorate, equivalent weight of zinc, weight of a liter of air, water of crystallization in copper sulphate (both stages), neutralization of normal acids and bases, etc. If along with these quantitative experiments the student is also taught the descriptive features and

* *British Association Reports,* 1900. Cf. SCIENCE, Vol. XII., p. 641, 1900.

qualitative tests of the substances studied, as well as the fundamental facts of physical chemistry (also recommended and elaborated by the Chicago conference), I should say that there we had a course eminently satisfactory. If time permits, a year might be spent with great profit on this work. Then should come a course of the same general order, but more difficult. Starting with a metal, a mineral or some technical product, the student should prepare a series of salts or other compounds of some ten or more metals. He should study the problem of obtaining the desired compounds; submit his plans to the instructor for criticism; prepare his substances, and analyze them qualitatively and quantitatively. The analyses should not be complete, but merely for effective purity and undesirable impurity; for *economy of labor should be taught,* and no work done that is not of direct value under the given circumstances. By a proper selection of material, the teacher will be able to present to his pupils, during two or three terms, all of the important qualitative and quantitative methods of separation. Nor is it necessary for each student to do exactly the same work; indeed, I should call it undesirable. Students would then learn from each other as well as from the teacher, and a laboratory 'atmosphere' would then be created where students may learn by a process of cutaneous absorption —as they seem to do in Germany. The work, moreover, should be reported regularly in the accompanying seminar; current and older periodical literature should be searched for additional information bearing on each student's topics; innumerable little opportunities for research will present themselves, and the most ought to be made of them; a well-planned course of lectures should parallel the laboratory work and expand its horizon, for the whole field of chemistry cannot be reviewed in the laboratory; and then, I venture to believe, the instructor will have a class of interested, if not enthusiastic, students. Special schemes of separation, the 'systematic' analysis now so widely current, the examination of milk and honey, can then be taught as the special things they are, and made to take their proper places in the economy of chemistry.

CONCLUSION.

In conclusion, allow me to summarize the propositions I have tried to maintain:

1. The practicing chemist, be he teacher, analyst or manufacturer, is of one kin.

2. For that reason, the training for these professions ought to be identical for *several* years, at least.

3. At present this training is inadequate.

4. There is needed a much broader foundation in pure chemistry.

5. The 'chemical instinct' needs cultivation.

6. Analytical training should be general rather than special.

7. The college should establish *bona-fide* courses in preparations, on a working scale.

8. Acquaintance with current thought must be fostered.

9. Time must be made for this program by cutting off all but the most important non-chemical topics.

10. Time can also be saved by eliminating qualitative analysis, because it is useless as an art and inefficient as a discipline.

11. The place of qualitative analysis should be taken by properly organized laboratory courses.

Perhaps it will be best to leave the twelfth and last conclusion to the charity of my hearers.

ARTHUR LACHMAN.
UNIVERSITY OF OREGON.

SCIENTIFIC BOOKS.

A Laboratory Manual of Botany. Outlines and Directions for Laboratory and Field Work in Botany in Secondary Schools. By Otis W. Caldwell, Ph.D. New York, D. Appleton & Company. 1902. Pp. ix+107.

This little book has for its chief characteristic a serious though perhaps not wholly successful attempt to give organization and direction to elementary work in plant ecology. Certainly the author deserves credit for making the attempt, for ecology will not be on a sure footing in secondary education until it becomes organized, and until the problems which are set have a definite character, and are commensurate with the mental ability of secondary students. As a general criticism pertinent to this remark we would be inclined to say that some of the work indicated is not above the abilities of students in the earlier grades, notably work in seed distribution and the like; while other parts of it are beyond the opportunities, certainly, if not the general intelligence of secondary students. At least, this is the feeling that the reviewer has in regard to the study of the ecology of plant societies.

The work is divided into two parts, consisting of sixty-two and forty-five pages, respectively, the first dealing with plants at work, the second with the structures of plants as they have developed in relation to the problems of nutrition and reproduction. Examining the second part at once, we do not notice that it deviates notably from the treatment of plants in the 'type course' as outlined in a good many text-books. We feel that the author has not indicated sufficiently clearly a definite line of thought, nor has he made, in some instances, the best choice of material. This appears notably in the treatment of the Hepaticæ, among which, as every botanist knows, we may find as interesting and instructive a series of types bearing on the general features of the evolution of the plant body, as may be found in the whole plant series. The study of such material may, we believe, very profitably be substituted for that suggested, viz., that of *Marchantia,* a by no means satisfactory type for the group when standing alone, on account of its very high degree of specialization.

Turning to the first part, we may consider it as a guide to laboratory and field work made necessary by a previously published work, Coulter's 'Plant Relations,' and it has, among others, the merit in particular that it puts the material and problems in, for the most part, fairly definite form. The reviewer cannot admit to have been won over as yet to belief in a course in ecology as an elementary course for the secondary school. He therefore sees much more to criticize than is, perhaps, wholly justified except upon general grounds. Such criticism applies therefore chiefly to the subject matter rather than to the book before him. For example, one is almost oppressed by the amount of knowledge which a student must be assumed to have in order to explain ecological problems placed before him. The work becomes, then, merely observational, or a mass of unanswerable questions. If the former, better in the elementary school; if the latter, better that it should be a subsidiary part of the course rather than the backbone, so to speak. Again, it would seem that the results which accrue from a lesson do not always justify the amount of material used.

The author that sets before himself the task of indicating problems in question form has not chosen the easiest one. Good questions are good things—among the best means to stimulate and guide the thought of the student. In this particular Dr. Caldwell has done well. The questions are, for the chief part, within the range of the student, and direct the mind from one observation to another in a satisfactory manner. The form of the question is sometimes unfortunate, pedagogically considered. 'Could,' introducing a question, involves deduction unnecessarily, that is, where the inductive method is the only sure one for the beginner at least.

The outlines will have, too, a stimulating effect upon field work, which should thereby be enhanced in value. This, by the way, is a feature of merit in the second part, in which field study is suggested and outlined, as for example in connection with the Algæ.

An introductory chapter containing some

suggestions for the equipment of the laboratory, and the use of the microscope, with, at the end of the volume, reference lists of dealers and materials, complete the volume, and increase its usefulness for secondary teachers and students, to whom it is on the whole by no means ill adapted. FRANCIS E. LLOYD.

The Cyclopedia of American Horticulture. By L. H. BAILEY and WILHELM MILLER. Comprising suggestions for cultivation of horticultural plants, descriptions of the species of fruits, vegetables, flowers and ornamental plants sold in the United States and Canada, together with geographical and biographical sketches. Vol. IV., R–Z. New York, The Macmillan Company. 1902. Pp. xxx+1487–2016; pl. 31–50; ff. 2060–2800.

Professor Bailey is to be congratulated on the completion of a work that will long stand as one of the monuments of horticultural progress, useful alike to the gardener, the student of cultivated plants and the seeker after general information relating to such plants.

The task he set himself was a hard one, for unless arbitrarily limited the field is a large one, the details intergrading and of unequal importance, and almost every step is beset with nomenclatorial and other pitfalls, between which a safe course is all but impossible because so many of the difficulties admit of only subjective solution which, when opinions differ, cannot please every one. With the good judgment but positive action for which he is noted, he has handled elaborate questions conservatively and as consistently as could be expected, considering that the several articles have been written by many persons whose opinions could hardly be reduced to a uniform level on any matter of policy.

The more notable parts of the concluding volume are the editor's preface, including a history of the planning and execution of the work and an outline for proposed supplements, and the articles on railroad-gardening, *Rhododendron, Ribes, Rosa* and rose, *Rubus, Salvia, Saxifraga, Scilla, Sedum,* seedage, *Selaginella, Sempervivum,* shrubbery, *Sorbus, Spiræa,* spraying, storage, strawberry, *Syringa,* tomato, transplanting, trees, *Tulipa, Ulmus, Vaccinium,* vegetable gardening, *Verbena, Viburnum,* village improvement, vines, *Viola* and violet, *Vitis,* walnut, wild garden, winter protection, and *Zea.* W. T.

The Science of Penology: The Defence of Society against Crime. By HENRY M. BOIES. New York and London; G. P. Putnam's Sons. 1901. Pp. 459.

The author of this book approaches his subject from the practical rather than from the scientific side, as is indicated at the outset by the fact that he is a member of the Board of Public Charities and of the Committee of Lunacy of the State of Pennsylvania. He makes no pretentious claims to originality; he wishes simply to 'collate and systematize' what others have done with a view to awaken a wider interest in the rational treatment of criminals and to assist those who make and execute the laws against crime. The really interesting and significant point about the book is that in a work which thus 'aims at practice' and is written by a practical man, the standpoint of those who during the last quarter of a century have sought—amid the ridicule of practical men—to put criminology on a scientific basis, is definitely accepted, and accepted almost as a matter of course. It is sufficient to mention the headings of the three sections into which the book is divided: Diagnostics, Therapeutics and Hygienics. In other words, from a book to which is attached the old-fashioned label of 'penology,' the subject of punishment is simply omitted altogether. At one point, it is true, the author would appear to admit the idea of punishment in so far as it may be of therapeutic value, but on the whole he has nothing whatever to say to it. "Criminal codes as they exist are," he states, "in the light of twentieth century intelligence, a conglomeration of penalties of various degrees of atrocity, irrationality, absurdity and inutility. They are the relics of blind social struggles against social evils, useful chiefly as antiquities, to be collected with thumb-screws, iron boots, racks, and torture wheels in mu-

seums. To provide an efficient substitute for these codes, to enunciate the principles upon which a successful defence of society against crime must be conducted and the abolition of criminality accomplished, is the special province and object of penology. * * * The supreme object of penology is to prevent crime, not to punish for it. It is similar to the science of medicine and surgery in that its province is not only to cure specific cases of disease, but also to prevent the genesis, recurrence and spread of disease." In this very radical statement, and in his assertion that 'criminality is a preventable and curable disease,' Mr. Boies goes further than most scientific criminologists are prepared to go. His absorption in his own subject also leads the author at times to regard the elimination of criminality as the main end for which the state exists, and to advocate unhesitatingly strenuous measures of somewhat dubious character, such as forbidding the marriage of various classes of criminals and even castrating them.

It must be said that the general tone of the book is distinctly dogmatic, and the author seldom appears willing to admit that any question can have two sides to it. He makes few references to authorities, and it may be gathered that his estimates as to the comparative values of authorities are somewhat uncritical. At the same time Mr. Boies has written a distinctly useful book. He may be described as a disciple of Ferri, adopting the same broad sociological standpoint as the eminent Italian author and making an attempt to adapt Ferri's principles to American conditions. It may be added that the book has been admirably produced by the publisher, and shows a praiseworthy absence of inaccuracies and misprints.

Havelock Ellis.

SCIENTIFIC JOURNALS AND ARTICLES.

The *Botanical Gazette* for April contains a continuation of Professor Frederick C. Newcombe's paper upon 'The Rheotropism of Roots.' It will be completed in the May number, when the principal results will be noted. Mr. John Donnell Smith publishes his 23d paper under the general title 'Undescribed Plants from Guatemala and other Central American Republics,' including descriptions of about twenty new species, and also of a new genus (*Donnellia*) of the Commelinaceæ, by C. B. Clarke. Accompanying the paper are two double page plates by C. E. Faxon. Miss Alice Eastwood concludes her 'Descriptive List of Plants collected by Dr. F. E. Blaisdell, at Nome City, Alaska,' describing new species of *Mertensia, Pedicularis, Pinguicula,* and *Aster.* Mr. E. B. Copeland discusses Haberlandt's 'New Organ of *Conocephalus,*' which he has called a substitute hydathode. Mr. Copeland shows that there is nothing very surprising or remarkable in the behavior of these structures, and that they are essentially similar to such as the same condition produces in many plants, the conditions being excess of moisture.

The American Naturalist for April begins with an article by Henry F. Osborn on 'Homoplasy as a Law of Latent or Potential Homology,' homoplasy being the independent similar development of homologous organs or regions giving rise to similar new parts. Applying this is to the teeth Professor Osborn finds that similar cusps have been developed in unrelated mammals in different parts of the world, and that there is some underlying principle which determines in a measure the course of evolution. Ales Hrdlicka presents some 'New Instances of Complete Division of the Malar Bone, with Notes on Incomplete Division,' and Herbert P. Johnson describes 'Collateral Budding in Annelids of the Genus *Trypanosyllis.*' This method is considered as an advance over linear budding and the genus as representing the most highly specialized mode of asexual reproduction among annelids. J. B. Johnston and Sarah W. Johnson discuss 'The Course of the Blood Flow in *Lumbricus*' in some detail, stating that their experiments give no support to the idea that there is a more or less complete segmental circulation in the genus. The notes and brief reviews are numerous.

The American Museum Journal for April contains an account, with illustrations, of an exhibit of birds' bills, feet, tails, wings and feathers, designed to illustrate terms used in

ornithology, as well as to call attention to the connection between the form and function of these parts. A course of lectures on the birds of spring is announced. The Supplement is a 'guide leaflet' to the collection of baskets from the graves of the ancient Indians of southeastern Utah, which comprises the oldest known baskets from this continent.

The Popular Science Monthly for May opens with a discussion of 'The Electronic Theory of Electricity' by J. A. Fleming, while a review of the 'Sulfuric Acid and Its Manufacture by Contact-process' is given by R. Kneitsch. Carl H. Eigenmann considers 'The Physical Basis of Heredity,' concluding that the chromatic threads are the carriers of hereditary power; the article is very clearly written and enlivened with touches of humor here and there. 'Children's Vocabularies' are discussed by M. C. and H. Gale, who show that these are, even for very young children, much more extensive than is generally imagined, and that they largely depend on what the children wish. Havelock Ellis presents an article on 'Mescal: A Study of a Divine Plant,' giving in detail the results of some experiments, and deciding against it as a therapeutic agent. 'Infectious Diseases' and their possible cure is by Alfred Springer and 'The Relations of Electrically charged Molecules to Physiological Action' by Jacques Loeb, while A. S. Packard describes 'An Afternoon at Chelles and the Earliest Evidences of Human Industry in France.'

Harper's Magazine for May contains an article on 'Marine Fish Destroyers' which fairly teems with erroneous statements and misleading deductions. It is only necessary to cite Dinosaurs one hundred feet in length, with a height of thirty feet and a thigh bone eight feet high, Mosasaurs seventy-five feet in length, and Zeuglodonts with limbs unknown, to show the exaggerated style of statement. The largest Dinosaur actually measured falls inside of seventy-five feet, and the largest femur found is six feet eight inches long, and but a single one of this size has ever come to light. Few Mosasaurs reached a length of forty feet and the vast majority are under twenty-five, while the limbs of Zeuglodon are known. The misleading deductions are as to the amount of fish destroyed by these animals, the writer not taking into account the fact that it is by no means proved that all these extinct animals lived so extensively on fish as is stated, and that it is not at all probable that they required a hearty dinner every day, much less obtained one. Worst of all is the inference that since so many fishes perish from natural enemies it makes no difference how many man captures, nor does it do any good to pass laws for their protection. Aside from the universal decrease of anadromous fishes which are particularly open to the attacks of man we have the notable decrease of the whitefish and Lake Trout of the Great Lakes, the noticeable diminution in the size of mackerel brought to market and the fact that the halibut fishery is now prosecuted at depths and distances once undreamed of. It would hardly be necessary to notice this paper at length but for the fact that the position and titles of its writer give undue weight to its statements in the mind of the reader, while its publication in a popular magazine spreads it broadcast and causes it to be read by hundreds who will not know that there is quite another side to the subject.

SOCIETIES AND ACADEMIES.

A PACIFIC SECTION OF THE AMERICAN MATHEMATICAL SOCIETY.

The mathematicians of the Pacific Coast held a meeting in San Francisco on May 3 and formally organized the second Section of the American Mathematical Society, to be known as the Pacific Section. The following officers were elected: Professor Irving Stringham, *Chairman;* Professor G. A. Miller, *Secretary;* Professor R. E. Allardice, Dr. E. J. Wilczynski and the secretary, program committee. The following papers were presented during the two sessions of the Section:

'On a Linear Transformation, with some Geometrical applications': Professor R. E. ALLARDICE, Stanford University.

'A Movement whose Centrodes are Cubics': Dr. E. M. BLAKE, University of California.

'On the Determination of the Analytic form of the Distance between two Points by means of Distance Relations': Professor H. F. BLICHFELDT, Stanford University.

'A Canonical form of the Binary Sextic': Professor M. W. Haskell, University of California.

'Constructive Theory of the Unicursal Cubic by Synthetic Methods': Dr. D. N. Lehmer, University of California.

'Algebraic Relations among the Integrals and the Reducibility of Linear Differential Equations: Dr. Saul Epsteen, Göttingen. (By title.)

'The Limits of the Minima of Definite Ternary Forms': Dr. J. H. McDonald, University of California.

'A Short Method of Deriving Osculating Elements of the Major Planets': Professor A. O. Leuschner, University of California.

'On the Groups of Genus One': Mr. W. A. Manning, Stanford University.

'Determination of all the Groups of Order p^m, which include the Abelian Group of Order p^{m-1} and of type $(1, 1, 1, ---)$': Professor G. A. Miller, Stanford University.

'On the Non-Abelian Groups in which every Subgroup is Abelian': Dr. H. C. Moreno, Stanford University.

'Dynamic Effect of Stationary Waves on Immersed Bodies': Mr. P. G. Nutting, Göttingen. (By title.)

'Concerning Quadruple Systems': Dr. T. M. Putnam, University of California.

'A Synthesis of Orthogonal Substitutions': Professor Irving Stringham, University of California.

'Congruences Defined by Functions of two Complex Variables': Mr. A. W. Whitney, University of California.

'Geometry of the Covariants of a Binary System of Linear Homogeneous Differential Equations': Dr. E. J. Wilczynski, University of California.

According to the By-Laws adopted by the Section there will be two meetings per year—one in May and the other in December. These meetings are to be held in or near San Francisco. The first Section of the American Mathematical Society, known as the Chicago Section, was organized in 1897 and also holds two meetings per year. The Society holds four meeting per year at Columbia University in addition to a summer meeting, which has generally been held in connection with the meetings of the American Association for the Advancement of Science.

G. A. Miller,
Secretary.

ANTHROPOLOGICAL SOCIETY OF WASHINGTON.

The 328th meeting was held March 11. A presentation of casts of the Neanderthal, Spy and Engis skulls was made by President W. H. Holmes and Dr. Frank Baker.

Professor Holmes placed the geologic time scale on the blackboard and located on it the various finds of fossil human remains, explaining the conditions under which the finds were made and the difficulties attending even approximate accuracy in determining their position.

From the somatological point of view Dr. Baker discussed the criteria of the determination of skulls and applied these to the crania under discussion. Dr. Baker said that the Neanderthal and Spy skulls are certainly not pathological as has been affirmed by some writers. Mr. J. D. McGuire in discussing the paper held that the man of Spy was possessed of classes of artifacts belonging to a much later period than students had generally admitted.

Dr. A. E. Jenks read a paper entitled 'Some Steps in Amerindian Economics.' This paper defined economic man as one who produces for use and future gain and affirmed that the American Indian north of Mexico had arrived at economic emancipation. Dr. Jenks outlined the study of economics in this field, giving the ramifications growing out of production for future gain and the effects on the development of the American Indian. The paper was heard with great interest and provoked an extended discussion participated in by Dr. J. Walter Fewkes, J. D. McGuire, Professor W. H. Holmes and Walter Hough.

The 329th meeting was held March 25, and was devoted mainly to technologic subjects.

Mr. Emil Berliner gave an interesting talk on the history of instruments for recording and repeating sounds, tracing the inventions from the eighteenth century to the present. The earliest form of phonograph with tinfoil sheets on which records of speech were made and gramaphone of the most recent type were exhibited and contrasted.

Mr. Fred. M. Tryon read a paper dealing with the development in hydrotechnics tracing the historic and ethnographic range of the in-

ventions applied to raising and distributing water and showing the tremendous strides made in the art at the present time.

Mr. P. B. Pierce's paper on wireless telegraphy presented in an attractive manner this most recent of the great inventions. Mr. Pierce pointed out the various steps by which wireless telegraphy came to be and called attention to the interaction of minds and inventions to produce new inventions. In conclusion Mr. Pierce explained the apparatus employed in wireless telegraphy.

The 330th meeting was held April 8.

Dr. Franz Boas of the American Museum of Natural History, New York, read a paper entitled 'Anthropological Organization in America.' The paper, which was prefaced with a review of the history of the existing societies, was devoted to a discussion of the question whether it is advisable to add a new organization to the number as has been lately proposed in the formation of an association of a national character, or to centralize and combine all such agencies in such manner as to strengthen the present and prospective organizations. Dr. Boas concluded that such work could be better done through Section H. of the American Association of the Advancement of Science, swarming from the parent hive as the Geological, Chemical and other Societies, from their respective Sections of some years ago.

In the discussion of Dr. Boas' paper, participated in by W J McGee, W. H. Holmes, Dr. George M. Kober, J. Walter Fewkes, and J. D. McGuire, there seemed to be a consensus of opinion that the new society should be of a national character, organized on broad lines, designed to promote the interests of anthropology in America. It was recognized that for convenience of meetings, etc., it might be advisable to maintain a connection with the American Association if such arrangement could be made.

A paper by Hon. A. R. Spofford followed, entitled 'Ceremonials, National, International and Social,' which was entertaining and instructive. Mr. Spofford rapidly sketched the wide range of ceremonial forms in time and their prevalence among uncultured peoples. The ultra forms of ceremonious politeness were held up to ridicule. WALTER HOUGH.

DISCUSSION AND CORRESPONDENCE.

THE VOLCANIC ERUPTION IN MARTINIQUE AND POSSIBLY COMING BRILLIANT SKY GLOWS.

THE terrific volcanic eruption in Krakatoa, near Java, in 1883, was productive of such brilliant phenomena in the sky and air and added so materially to our knowledge of the motions of the atmosphere that meteorological observers would do well to watch for the earliest appearance of similar phenomena from the recent outbursts in the West Indies. Such observations may aid greatly in the study of the motions of the air.

Up to the date of the Krakatoa explosion, it had been supposed by meteorologists that the air forming the trade winds approached the equatorial belt from both sides and ascending near the equator turned toward the poles, becoming a southwest upper current in the northern hemisphere and a northwest upper current in the southern hemisphere, flowing over the trade winds below.

The observations on the Krakatoa phenomena gathered by the committee of the Royal Society and discussed by Russell and Archibald show that the upper currents in the tropics between 20°N. and 20°S. moved from the east with a velocity of about 75 miles an hour. This was indicated by the progress of the haze and sky glows which were traced around the world three times in succession. (See 'The Eruption of Krakatoa and Subsequent Phenomena,' London, 1888.) The very fact that the authors were able to follow the dust cloud and its attendant phenomena indicates that the upper air movement within this belt is very uniform in velocity and direction, otherwise the cloud of smoke and haze would have very quickly disintegrated and it would have been impossible to trace it even once around the world with a nearly parallel front as was done by Russell.

These observations were not in accord with theory and it was at first supposed they might be due to temporary movements of the atmosphere. But Abercromby was so much impressed by the phenomena that he began to

gather observations of cirrus within the tropics (see *Nature*, 1887–1889). These observations were followed by the systematic work of Hildebrandsson who has shown that the prevailing motion of the cirrus between 20°N. and 20°S. is from the east. Above these latitudes the prevailing cirrus motion is from the west.

It is probable that between these two regions of opposing winds there is a narrow belt of comparative calm across which the air moves very slowly from the equator. The spread of the dust from Krakatoa across this region apparently did not exceed a velocity of one mile an hour, so that it was two months or more after the eruption before sky glows were observed in high northern latitudes.

It is evident that observations on the sky glows following volcanic eruptions are very desirable for the study of the atmosphere. It is thought that some bright sunsets observed at Blue Hill last autumn may have been connected with a volcanic eruption in May in Java and subsequent brilliant sunsets in Mauritius described by Claxton. If notes were made elsewhere of unusually brilliant sunsets we should be glad to receive them at this Observatory and also accounts of such sky phenomena as may follow the eruption at Martinique.

Henry Helm Clayton.

Blue Hill Observatory,
May 10, 1902.

THE WORD 'ECOLOGY.'

To The Editor of Science: After the full discussion of the origin, history and use of the word *ecology* in Science for April 11, it is certainly surprising to read the inexcusably erroneous statements about this word by Mr. F. A. Bather in the current number of the same journal. After correctly stating the meaning of the word, Mr. Bather goes on to say: "Haeckel and biologists generally have used the word in the above sense, but of recent years the botanists have wrested, or at least restricted, the meaning of the term to the study of the associations of plants in such groups as alpine, sand-dune and desert plants; and this is the sense intended on pp. 458, 459 of Science for March 21. In a word they have used 'œcology' instead of 'œcological plant geography.'" This statement is extremely misleading if not wholly erroneous. It is possible that some writers have so restricted the term, but I cannot recall any case of it. Mr. Bather cannot surely here refer to Cowles's use of the phrase 'physiographic ecology,' because Cowles, in his elaborate paper in which he introduces the phrase expressly defines ecology in its full scope and shows that his use of the term is by no means an attempt at a restriction of it. Botanists, universally as far as I know, use the word in very nearly if not exactly its original broad sense, as applying to all forms of adaptation of organisms to their environment, and hence it is perfectly proper to apply it to plant associations when studied from the point of view of adaptation. If it were needful I could cite columns of references to prove this usage, but I will simply refer to the fact that ecology is used in its broad sense, with no attempt at such restriction as Mr. Bather avers, in all the modern botanical text-books including Campbell's 'University Text-Book' just issued, in a recent official publication ('Report on a College Entrance Option in Botany') by the Society for Plant Morphology and Physiology, and in many recent special papers upon plant adaptations.

Quite inexcusable, further, is Mr. Bather's statement that Robert Smith, in his justly praised paper on the 'Study of Plant Associations' (in *Natural Science* for February, 1899) does not mention the word œcology. Smith uses it no less than four times in that paper. Thus on page 113, Smith says, "Reiter (1885) modified Grisebach's scheme of plant forms to reconcile it with later research in plant œcology." Again on page 112, Smith says, "In the bibliography at the end of this paper a few only of the chief of these have been mentioned as representative œcological works, dealing with such marked forms of vegetation as strand plants, aquatic plants, halophytes, desert plants, etc." And he uses œcological again in the footnote at bottom of page 115, and again, on page 110. Mr. Bather's implication that Smith did not use the word œcology in connection with plant

associations is therefore without foundation. In fact Smith used the word precisely as other botanists are using it to-day.

Mr. Bather calls the form *ecology* a 'vagary of incorrect spelling' of *œcology*. The shorter spelling was formally recommended in 1893 by the foremost botanical organization in this country, on the general ground that the same considerations which make *economy* preferable to *œconomy* make *ecology* preferable to *œcology*. The recommendation has been followed by practically all writers on botanical subjects in this country and occurs in nearly all of the botanical works of the highest educational and scientific standing in America, (Campbell's recent text-book is the only exception I have noticed), and in most if not all papers now appearing based on original work upon adaptations. Whether under these circumstances the form ecology can be properly described as a vagary of incorrect spelling I leave the reader to judge.

W. F. GANONG.

TO THE EDITOR OF SCIENCE: In spite of the number of letters written with regard to the word ecology, the fact has been overlooked that the Standard Dictionary gives ecology, so spelled, with a cross reference to œcology, and so it is a great mistake to say that the newest spelling is not in the latest dictionary. It seems only just to the Standard Dictionary that this statement should be made.

WALLACE CRAIG.

HULL ZOOLOGICAL LABORATORY.

IN view of the recent discussion as to the tardy recognition of scientific terms by the dictionaries, it may be interesting to note that the word *tropism* which is now so commonly used in the discussion of the origins of motor reactions in organisms does not appear in any of the dictionaries (including the 'Century') that are accessible to me. Neither this term nor the term *ecology* belong to the class of narrow technical terms but would demand general definition on account of their comprehensive connotation. I am not aware of the origin or the exact degree of recentness of the term *tropism;* but my impression is that it has been used sufficiently long to have secured some recognition. Still it must be remembered that the word *appendicitis* was not current enough when the first volume of the 'Century Dictionary' appeared, to warrant its inclusion.

JOSEPH JASTROW.

INDIAN SUMMER.

TO THE EDITOR OF SCIENCE: I wish to call the attention of your readers to the exhaustive articles on the origin of the term Indian summer, which is published in the *Monthly Weather Review* for January and February of this year. Mr. Albert Matthews (145 Beacon Street, Boston, Mass.), the author of this memoir, has spared no labor in collecting the early examples of the use of this term. Its first recorded appearance is in the year 1794 in the journal of Major Ebenezer Denny for October 13, 1794, while at Le Boeuf, a few miles from the present city of Erie, Pa., and there can be no doubt but what the term was in extensive use and well recognized at that time. Since that date numerous explanations have been given by different persons as to the origin and original meaning of the term, but these are of the nature of myths or hypotheses and it is very much to be hoped that we shall yet discover earlier cases and the true history of its introduction. We shall be very glad to hear from any one who can add anything of value to the elaborate paper by Mr. Matthews.

CLEVELAND ABBE.

WEATHER BUREAU,
U. S. DEPARTMENT OF AGRICULTURE.

BOTANICAL NOTES.

NATURE STUDY.

WE have had all sorts of books on 'Nature Study,' and for the most part they have been an abomination with nothing to redeem them, possibly with the exception that the authors 'meant well.' Enthusiastic persons who knew nothing exactly about nature, and still less about children, wrote impossible lessons for the pupils in the schools, and too often the superintendents knowing no more in regard to either, 'adopted' these misbegotten productions, and issued instructions to teachers to dole out so many pages a week to the defense-

less pupils in their charge. What botanist has not seen these books which are filled with gush and nonsense, and nothing more? A few days ago a new book on nature study appeared, and it did not require long examination to show that it is of an entirely different order. It was prepared by Professor Hodge of Clark University, and it is not too much to say that it is by far the best and *sanest* book on this subject that has yet appeared. The inevitable result of such work as the author outlines will be the greater love of nature by the child, and yet we do not find that pupils are urged and admonished to 'be good children, and love nature.' There is absolutely nothing of this kind, yet the book is eloquent in suggestions of the lovableness of plants, and birds, and insects, and all manner of creeping things. The namby-pambyism which the healthy-minded boy so properly hates and despises is wanting, and in place of it are the most suggestive of photographs, and descriptions of things that live, and are waiting to be seen by sharp-eyed children. The book must be seen to be known, but a few of the chapter headings will give some idea of the treatment. 'Children's Animals and Pets,' 'Insects of the Household,' 'Garden Studies, Home and School Gardens,' 'Propagation of Plants,' 'Common Frogs and Salamanders,' 'Our Common Birds,' 'Practical Domestication of our Wild Birds,' 'Elementary Forestry,' 'Flowerless Plants,' are some of the titles. The book will no doubt find its way into many schools, and it should drive out the swarm of worthless volumes that have preceded it.

OUR KNOWLEDGE OF THE FUNGI.

The sixteenth volume of Saccardo's Sylloge Fungorum, which has just made its appearance enables us to judge of the rapidity with which mycologists are describing the species of fungi. The last preceding supplementary volume containing descriptions of added species, appeared in August, 1899, so that but little more than two and a half years have passed, and yet we have here an aggregation of 4,314 descriptions, and an appendix of 539 new species and varieties for which the descriptions are not generally given. These 4,853 additions to previously described species bring the total number in the work as a whole up to 52,157. If we make no allowance for synonyms and descriptions of 'forms' this is the total number of fungi now known. The additions in this volume are divided as follows: Hymenomyceteæ, 886; Gasteromyceteæ, 120; Uredinaceæ, 523; Ustilaginaceæ, 79; Phycomyceteæ, 55; Pyrenomyceteæ, 1,102; Laboulbeniaceæ, 231; Discomyceteæ, 466; Deuteromyceteæ ('Fungi Imperfecti'), 1,367. A general index to all of the volumes, I. to XVI., completes the volume.

PACIFIC SEASIDE BOTANY.

For the past ten years there has been maintained at Pacific Grove, two miles west of Monterey, California, a summer school of investigation, under the name of the Hopkins Seaside Laboratory, in which exceptional opportunities for botanical study have been afforded. The session this year opens June 9, and continues for six weeks and the botanical work is to be under the direction of Dr. A. A. Lawson. In addition to the usual general course in botany, there are courses for advanced students in the marine algæ, cytology, and microtechnique. The well-known richness of the marine flora of this part of the coast renders work in this laboratory especially instructive. There are two two-story buildings capable of accommodating eighty students, which are used for laboratories. As the Laboratory is a branch of the biological departments of Leland Stanford Junior University, the facilities are certain to be complete as to apparatus, libraries, etc.

A thousand miles north of Monterey is another seaside station, at Port Renfrew, Vancouver Island, under the charge of Professor MacMillan, of the University of Minnesota. It was established last year, and a successful session was held. This year the session opens about the middle of July and extends to the 1st of September. Botanical instruction will be given on the Phæophyceæ (MacMillan), Rhodophyceæ (Yendo), Chlorophyceæ and Cyanophyceæ (Tilden). The results of the first session lead us to look for work of a high order at this station. The brown seaweeds (Phæophyceæ) are represented by an un-

usally large number of species, and are very abundant. Certainly the Pacific Coast botanists are to be congratulated upon having two such excellent stations for study and research.

MULTIPLICATION OF SPECIES IN BOTANY.

IT is never safe to 'call a halt' in any department of science, much less in a department in which one is not himself a specialist; yet such non-specialist may be permitted to give his impressions as an interested on-looker from another part of the field. And as it often happens that the soldier in a different part of the field of battle is able to see more clearly what is taking place than those in the thick of the mêlée, so it may be that botanists just a little outside of the work of descriptive systematic botany are able to measure the real value of some of the work now being done. One can hardly take up a botanical journal without finding that some of the common species of plants have been split into two or more forms called 'species' by their authors. That such work must be done is inevitable, but it is incredible that ten to twenty species should have been able to hide themselves in plants which had been critically studied by such masters as Gray, Torrey and Watson. As long as these leaders were found to have confused only two or three species in one the interested on-looker was ready enough to accept the dictum of present-day specialists in single genera, and to admit that the masters had blundered, but when we are asked to believe that Gray and Torrey were totally blind and incapable of seeing or defining the limits of species, it is evident that these later workers are dealing with something of which their predecessors either knew nothing or cared nothing when they were defining species. In 1878 there were catalogued for North America in Watson's Bibliographical Index 14 species and 10 varieties of hawthorns, of the genus *Cratægus*. In 1899 these numbers had risen to 34 species and 11 varieties. To-day we are asked by several botanists to add to this list 225 new species almost entirely from the eastern United States, where three years ago there were not *one tenth as many!*

Of course this brings up the old question of the limits of species. This can not be discussed in a short note, but this is certain, that in the case cited we are asked to give greater values than formerly to observable variations. This is carried to such an extreme that one is compelled to ask whether this change is warranted. Are not these new species merely local variations, or in some instances individual variations? The ornithologists have noticed similar minute variations in birds, although they have not regarded them as specific, but rather varietal, or sub-varietal. Yet there are ornithologists who question the wisdom of requiring that all members of a particular subvariety should have been taken 'under the same blackberry bush.' Are not the botanists who are making so many species open to a similar criticism? If in *Cratægus* we have species with such slight variations, what are we to do with the varieties of the common apple trees? We shudder at the thought of these species-multipliers getting into our orchards. There must be at least a thousand or so good 'species' hidden in *Pirus malus* of Linnæus!

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

THE COLLECTED PHYSICAL PAPERS OF HENRY A. ROWLAND.

A VOLUME containing the physical papers of Professor Henry A. Rowland, for twenty-five years professor of physics in the Johns Hopkins University, is now in preparation. It will be issued under the editorial direction of a committee appointed for that purpose, consisting of President Remsen, Professor Welch and Professor Ames. The book will contain Professor Rowland's articles and memoirs on physical subjects, together with his popular writings and addresses, numbering sixty in all. These have been collected from over twenty different magazines and journals. The subjects treated in these papers cover a wide range. In heat there is the great memoir on the mechanical equivalent of heat, with several shorter articles on thermometers. In electricity and magnetism there are the fundamental researches on magnetization, on the magnetic effect of electrical convection, on the value of the ohm, on the theory and use of alterna-

ting currents, etc. In light there are the renowned discovery and theory of the concave grating and the long series of investigations made in the field of spectroscopy. List of wave-lengths will not be reprinted in this volume, as they are readily accessible elsewhere; and any subscriber to this volume may obtain by application to the Johns Hopkins Press, Baltimore, a copy of Rowland's 'Preliminary Table of Solar Wave-lengths.' There will be, further, a description of Rowland's ruling engine, used for the making of gratings, details of which have never before been published.

The Memorial Address of Professor Mendenhall; published in SCIENCE, and a portrait of Professor Rowland will also be included.

The volume will be printed in royal octavo, bound in cloth, and will contain between six and seven hundred pages. The price set is five dollars per copy for orders sent in advance of publication.

Orders may be sent to Professor Joseph S. Ames, Secretary of the Committee of Publication, Johns Hopkins University, Baltimore, Maryland.

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*THE INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.**

THE Third International Conference on this subject, held in London during June, 1900, after considering the questions left in abeyance by the two previous Conferences, decided to publish an annual book catalogue arranged according to both an author and a subject index of the following named sciences: Mathematics, Mechanics, Physics, Chemistry, Astronomy, Meteorology (including Terrestrial Magnetism), Mineralogy (including Petrology and Crystallography), Geology, Geography (Mathematical and Physical), Paleontology, General Biology, Botany, Zoology, Human Anatomy, Physical Anthropology, Physiology (including Experimental Psychology, Pharmacology and Experimental Pathology), and Bacteriology.

Government aid was offered by many of the countries represented by delegates. The catalogue was to consist of an index to all original contributions to science published after January 1, 1901. Regional bureaus were to be established in the several countries charged with the duty of furnishing to the Central Bureau an index of the scientific literature of their respective countries. The price of the catalogue was fixed at $85 per annum for the 17 annual volumes, subscriptions to be made for a period of five years. At the present time the affairs of the catalogue are as follows: The United States Government having as yet failed to contribute toward the support of a regional bureau, the Smithsonian Institution has temporarily undertaken the work.

The equivalent of over 71 complete sets, representing over thirty thousand dollars, have been subscribed for in the United States.

In February the Central Bureau reported that over fifty-one thousand catalogue slips had been received from the Regional Bureaus.

The first parts of Chemistry and Botany will be published during the present month, to be shortly followed by parts of Physics and Physiology. It was found necessary to publish these first volumes in two parts. The next publications will be the complete volumes of Mathematics, Astronomy, Meteorology and Bacteriology for 1901. Single volumes may be subscribed for at their proportional value. A provision has been made for those desiring a card index to print some of the sets on one side of the leaf only in order that the separate entries may be mounted on cards. The charge for the volumes so printed will be about one sixteenth in addition to the cost of the regular form.

* Abstract from a paper on the International Catalogue of Scientific Literature read before the American Philosophical Society, April 4, 1902, by Cyrus Adler, Ph.D. (For fuller history see SCIENCE, August 6, 1897, June 2 and 9, 1899. Also reports of the First, Second and Third International Conferences, published by the Royal Society, of London.)

SCIENTIFIC NOTES AND NEWS.

THE degree of LL.D. was conferred on Lord Kelvin by Yale University on May 5, this being the first time for over a hundred years that the University has held a special assembly for the conferring of an honorary degree. Lord Kelvin was presented for the degree by Professor R. H. Chittenden, director of the

Sheffield Scientific School. President Hadley in conferring the degree said: "You have joined the different regions of the earth by your investigations of the submarine telegraph; you have joined the different realms of human thought by your contributions to physical theory." Lord Kelvin last week paid various visits, especially to the electrical laboratories of New York City, and sailed for England on May 10.

THE Bavarian Maximillian Order for Science and Art has been conferred on Professor J. H. van't Hoff, professor of general chemistry in the University of Berlin.

THE seventieth birthday of Professor von Leyden, the eminent pathologist, known especially for his work on diseases of the spinal cord and on tuberculosis, was celebrated at Berlin on April 20. In addition to the presentation of a *Festschrift* and other marks of esteem, a fund for research was established amounting to about $11,000.

DR. ALEXANDER AGASSIZ has been appointed director of the Museum of Comparative Zoology of Harvard University.

THE Geographical Society of Philadelphia has awarded to Lieutenant Robert E. Peary the Elisha Kent Kane medal. It was received by Mrs. Peary on her husband's behalf.

DR. ABRAHAM JACOBI, of Columbia University, has been elected as chairman of the American Committee of the Fourteenth International Medical Congress to be held at Madrid a year hence. Dr. Howard A. Kelly, of Johns Hopkins University, will deliver the address at one of the general meetings of the Congress, and has chosen for his subject 'The Passing of a Specialty.'

DR. J. L. WORTMAN, of the Peabody Museum of Yale University, will be in the West until September, exploring the fields in Dakota, Wyoming, and the Bad Lands, where the late Professor Marsh made his important paleontological discoveries.

ERNST A. BESSEY, in charge of the Section of Seed and Plant Introduction in the United States Department of Agriculture, has been detailed to proceed to Russia, the Caucasus, and Turkestan for the purpose of securing certain seeds of forage and cereal plants. He is to sail on July 2.

AN expedition to northern Brazil will be sent out by the Austrian Government in the autumn under the direction of Dr. M. Steindachner, curator in the Vienna Museum of Natural History.

A BRONZE tablet in memory of Professor James H. Coffin, the eminent meteorologist, for many years professor of mathematics at Lafayette College, has been presented to the College by the class of 1866.

WE regret to record the death of Henry Morton, the eminent engineer, president of Stevens Institute of Technology since its foundation in 1870. We hope to publish a notice of President Morton's life and work.

COLONEL MALCOLM WILLIAM ROGERS, who carried on important engineering work in India, died on April 25 at the age of sixty years.

M. HENRI FILHOL, professor of paleontology at the Jardin des Plantes, Paris, and the author of numerous important contributions to this science, has died at the age of sixty years.

IMMANUEL LAZARUS FUCHS, since 1884 professor of mathematics in the University of Berlin, died on April 26 at the age of sixty-eight years.

DR. E. VON PFLEIDERER, professor of philosophy at Tübingen, has died at the age of sixty years.

THE mineralogist, Friedr. Baron Rosen, has died at Kassan at the age of sixty-eight years.

THE seventeenth annual meeting of the Association of American Physicians was held in Washington on April 29 and 30, Dr. J. C. Wilson presiding. Officers for next year were elected as follows: *President,* James Stewart, Montreal; *Vice-President,* William T. Councilman, of Boston; *Secretary,* Henry Hun, of Albany, N. Y.; *Treasurer,* J. P. C. Griffith, Philadelphia, and *Recorder,* S. Solis Cohen, Philadelphia. A proposition was made that will be voted on next year to increase the membership of the Association from 125 to 150.

The agricultural appropriation bill, as introduced in the House, carries an appropriation of $5,115,570. Compared with the current fiscal year the appropriations are as follows:

	Current fiscal year.	1902-3.	Increase.
Office of Secretary	$71,670	$73,690	$2,020
Weather Bureau...	1,148,320	1,251,760	103,440
Animal Industry...	1,154,030	1,247,180	93,150
Plant Industry....	496,680	601,780	105,100
Forestry.....	185,440	282,860	97,428
Chemistry.....	35,800	73,200	37,400
Soils.....	109,140	168,960	59,820
Entomology.....	36,200	57,200	21,000
Biology.....	32,800	45,600	12,800
Accounts.....	18,900	24,100	5,200
Publications.....	198,020	228,020	30,800
Experiment stations	789,000	792,000	3,000
Silk investigations.	Nothing.	10,000	10,000
Total increase.	.....	.....	581,150

The appropriations in recent years have been as follows:

For 1897–98 the appropriation was $3,182,902.

For 1898–99 it was $3,509,202, an increase of $326,300.

For 1899–1900 it was $3,726,022, an increase of $216,820.

For 1900–1901 it was $4,023,500, an increase of $297,478.

For 1901–2 it was $4,582,420, an increase of $558,920.

Eighty-three thousand acres of forest land have been purchased by the State Forestry Commission in Central Pennsylvania.

The 73d anniversary meeting of the Zoological Society, of London, was held on April 29. The report of the council for the past year was read by Mr. P. L. Sclater, secretary. It stated that the number of fellows on December 31 last was 3,338, an increase of 88 on the corresponding period of the previous year and showing a larger number of fellows on the Society's books than in any year since 1879. The income of the Society during the past year has been £29,350, showing an increase of £577 over that of the previous year. The ordinary expenditure for 1901 had amounted to £27,526, being £1,187 more than the ordinary expenditure of 1900. The extraordinary expenditure paid in 1901, amounting to £4,530, had been devoted entirely to new buildings and works. The balance carried forward on December 31 last was £1,121. The number of animals living in the Society's gardens on December 31 last was 2,922, of which 789 were mammals, 1,575 birds, and 558 reptiles and batrachians. Amongst the additions made during the past year ten mammals, 58 birds, 21 reptiles, three batrachians, and two fishes were registered as new to the collection. The Earl of Crawford, Mr. F. Du Cane Godman, Dr. A. Günther, Sir Harry Johnston, and Mr. E. Lort Phillips were elected into the council in the place of the retiring members. The Duke of Bedford was reelected president, Mr. Charles Drummond treasurer, and Mr. Sclater secretary of the Society for the ensuing year.

A physiographic Conference will meet at the State Normal School, Westfield, Mass., Saturday morning, May 17, at ten o'clock. The subject to be discussed at the forenoon session will be 'Laboratory Work on Features of the Land for High and Normal Schools.' The discussion will be opened by Professor Richard E. Dodge, of the Teachers College, Columbia University, Miss Mary I. Platt, of the Brookline High School, and Mr. William H. Snyder, of the Worcester Academy. In the afternoon, Professor William Morris Davis, of Harvard University, will conduct the members of the conference over the Westfield terraces.

Professor Frederick Starr, of the University of Chicago, has issued a series of type portraits of South Mexican Indians. The series includes sixty platinum photographs, which represent thirty subjects, front and profile views being given of each. Twenty-three men and seven women make up the series. There is one man from each of the tribes that Professor Starr has visited. The portraits are simple heads, and are of actual size of life. Only fifty sets, are to be issued.

According to cablegrams to the daily papers, Professor Behring has published a book in Berlin proving that the bacilli of human and bovine tuberculosis are identical, the seeming differences between them resulting from the capacity of the bacilli to accommodate themselves to the organism in which they live. The writer says he has successfully infected cattle with virus from human beings, produ-

cing thereby fatal animal tuberculosis. He also says he has rendered cattle immune against tuberculosis by vaccinating them when they are young.

AT the annual meeting of the California State Medical Society, held April 15–17, the following resolution was adopted: "Whereas, the Mayor of the city of San Francisco has seen fit to remove the so-called old Board of Health; and whereas, the chief executive of the city has stated that he has determined, after a prolonged personal investigation, that bubonic plague has never existed in San Francisco; and whereas, the position is absolutely unsupported by any competent, unprejudiced physician who has made personal examination of suspects or alleged cases of plague before or after death, or who has examined the bacteriological evidence presented, and is further in direct conflict with the findings of the Federal Government experts and Special Commission; therefore be it *Resolved,* That the Medical Society of the State of California emphatically condemns this action on the part of the Mayor of San Francisco, and at the same time endorses the position always maintained by the old Board of Health in its sanitary defence of the people of the city of San Francisco and of the country at large.

WE have been requested to print the following note:

Between September 21 and September 28, 1902, the Association of Natural Phylosophers and Physicians will hold its 74th Annual Congress at Carlsbad, the Austrian Spa. As on former occasions the rule that lectures and debates may be carried on in any language of the world, will be adhered to, and to English, American, French, Spanish, etc. Natural Phylosophers and Physicians the same privileges will be again accorded as the ordinary members of the association are in the habit of enjoying. It is estimated that between 6,000 and 8,000 representatives of Natural Phylosophy and Physicians will gather on that occasion at Carlsbad, and great preparations are made now already, at Carlsbad, to receive the members and friends of this famous association. Nearly all the principal professors of the Berlin, Vienna, Prague and most of the other Continental universities and high colleges will again be present, and 28 different branches of modern and ancient sciences will form the programme for the lectures and debates. As several hundred inhabitants of Carlsbad understand and speak English, the place being annually frequented by a few thousand bathers and tourists from England and America, the facilities, comfort and convenience available for English and American Natural Phylosophers and Physicians, at this year's congress, will be by far greater than on any former occasion, but those intending visitors of the congress who wish to hold lectures should give notice of this intention at an early date, as the number of lecturers will be very large. We are requested by the secretary of the association to inform our readers that this Association of Natural Phylosophers and Physicians pursues solely and exclusively the object of promoting and developing all branches of science, and that any other object of whatever kind it may be, is strictly excluded. At the small exhibition of scientific objects which will be held in connection with the Congress, no charge will be made to exhibitors for the space required, nor will any entrance fee be asked from visitors. Enquiries or letters should be addressed to 'The 74th Congress of Natural Phylosophers at Carlsbad.' No stamp for reply need be enclosed.

WE learn from the London *Times* that Major Ronald Ross has submitted to Sir Alfred L. Jones, chairman of the Liverpool School of Tropical Medicine, a report on the anti-malaria work accomplished on behalf of the school in Freetown by Dr. Logan Taylor since his arrival last July. Employing about seventy men, Dr. Taylor has drained nearly the whole of the most pestilential parts of the town. The areas which have been dealt with were formerly full of hollows, pits and ill-made drains, which in the rainy season contained pools of stagnant water, breeding swarms of malaria-bearing mosquitoes. In addition to the work of drainage Dr. Taylor has employed a gang of men to collect old tins, bottles and other rubbish from the houses, and 2,257 cart-loads of such refuse have been removed and 16,295 houses have been visited. The effect of these measures has been a demonstration of the possibility of getting rid of mosquitoes in Freetown, and therefore, probably, in any town. The moral which Major Ross draws from the results of the work done is that in order to make the principal West African stations healthy they must be rendered scrupulously dry and clean. Nothing else will remove the

malaria in them on a large scale. To attain this object the colonies must be prepared to maintain proper conservancy gangs, superintended by efficient health officers. As regards the effect of the anti-mosquito measures on the health of Freetown, Major Ross says that he was struck by the great change in the demeanor of the Europeans. Two and a half years ago every one was gloomy; now the Europeans look as cheerful and well as they look in India. Arrangements have been made for Dr. Taylor to proceed at once to Cape Coast, in order to start anti-malaria work there, with the assistance of the governors, as the mortality at present is very high.

We take from the Mexican *Herald* the following recommendations passed by the second International Conference on January 29: The second international American conference recommends to the republics here represented, that an 'American International Archeological commission' be formed, through the appointment, by the president of each of the American republics, of one or more members of such commission; that each government represented shall defray the expenses of its commissioner or commissioners; that such commissioner shall be appointed for five years, and that they shall be subject to reappointment; that appropriations for the expenses incidental to the prosecution of the work and publications of the reports of the archeological commission shall be made by the respective governments subscribing on the same basis as that on which the bureau of the American republics is supported; that the first meeting for the organization of the commission, the election of officers and adoption of rules, shall occur in the city of Washington, District of Columbia, United States of America, within two years from this date; that the accounting department of the commission shall be exercised by the bureau of the American republics; that this commission shall meet at least once in each year; that the commission shall have the power to appoint sub-commissions, which shall be charged specially with the explorations, or other work committed to their care; that sub-commissions may be appointed, which shall cause the cleaning and preservation of the ruins of the principal prehistoric cities, establishing at each of them a museum to contain objects of interest; to found an 'American international museum' which is to become the center of all the investigations and interpretations, and that it be established in the city selected by the majority of the republics acquiescing in this recommendation. Committees shall also be appointed to clean and conserve the ruins of ancient cities, establishing in each of them a museum to contain the antiquities that may be gathered, and which is to afford all possible accommodations to the visitors. The archeological commission and the subcommittees it may appoint will be subject in all matters to the laws of the signatory countries.

UNIVERSITY AND EDUCATIONAL NEWS.

President Schurman took the occasion of Lord Kelvin's visit to Cornell University to announce that the necessary $250,000 required by Mr. John D. Rockefeller's gift was assured, and that $250,000 will be spent in erecting a hall of physics.

Yale University has been made the residuary legatee of Edward W. Southworth, New York City, and it is said may receive as much as two or three hundred thousand dollars from the estate.

Vassar College has received a library building from a donor whose name is at present withheld.

Dr. A. E. Kennelly, of Philadelphia, has been appointed professor of electrical engineering at Harvard University.

Dr. Abraham Jacobi has resigned the chair of the diseases of children in Columbia University.

Dr. B. F. Kingsbury has been appointed to the chair of human physiology in Cornell University. At present Dr. Kingsbury is at the University of Freiburg; he will assume his duties for the college year 1903–1904. Meantime the classes in physiology will be instructed by Professor B. G. Wilder and Dr. P. A. Fish.